March 13, 1962 P. R. HASKELL ET AL 3,024,530

CARTRIDGE-POWERED PISTON TYPE TOOL

Filed May 10, 1955 12 Sheets-Sheet 1

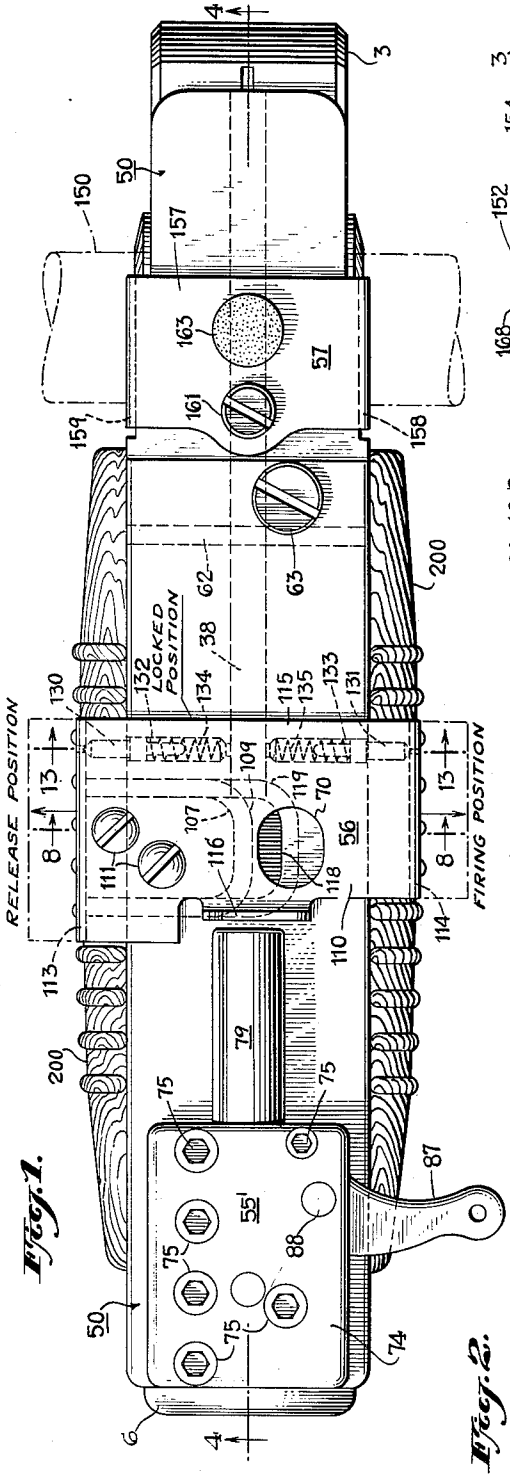


Fig. 1.

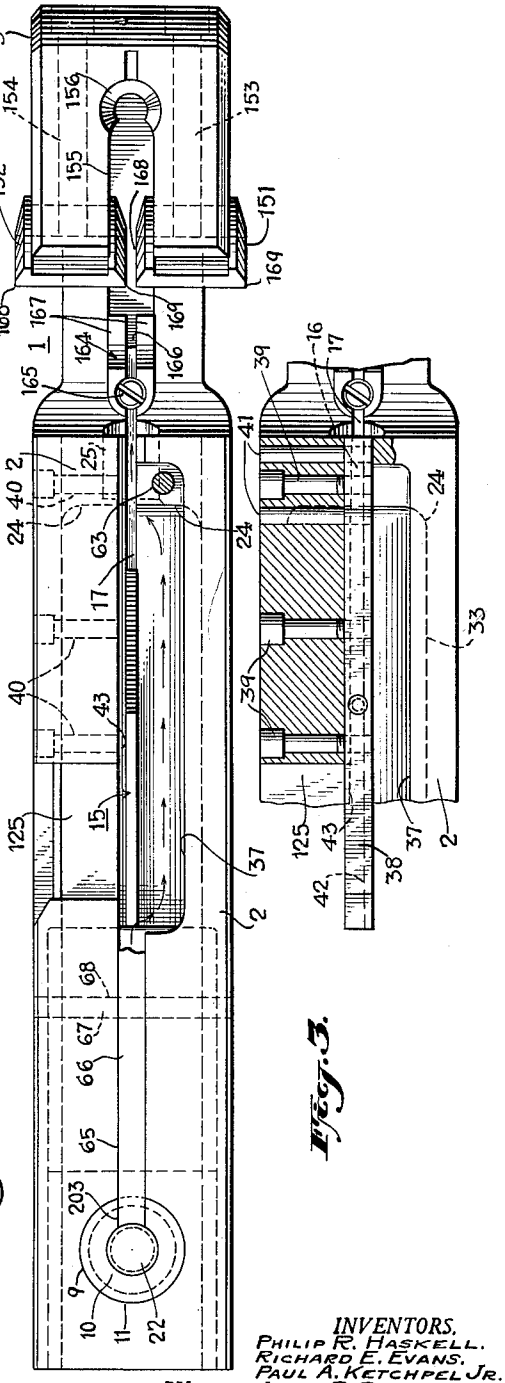


Fig. 2.

Fig. 3.

INVENTORS,
PHILIP R. HASKELL.
RICHARD E. EVANS.
PAUL A. KETCHPEL JR.
LYLE B. CONNOR.

BY

John H. Lewis Jr.
ATTORNEY.

March 13, 1962 P. R. HASKELL ET AL 3,024,530

CARTRIDGE-POWERED PISTON TYPE TOOL

Filed May 10, 1955 12 Sheets-Sheet 2

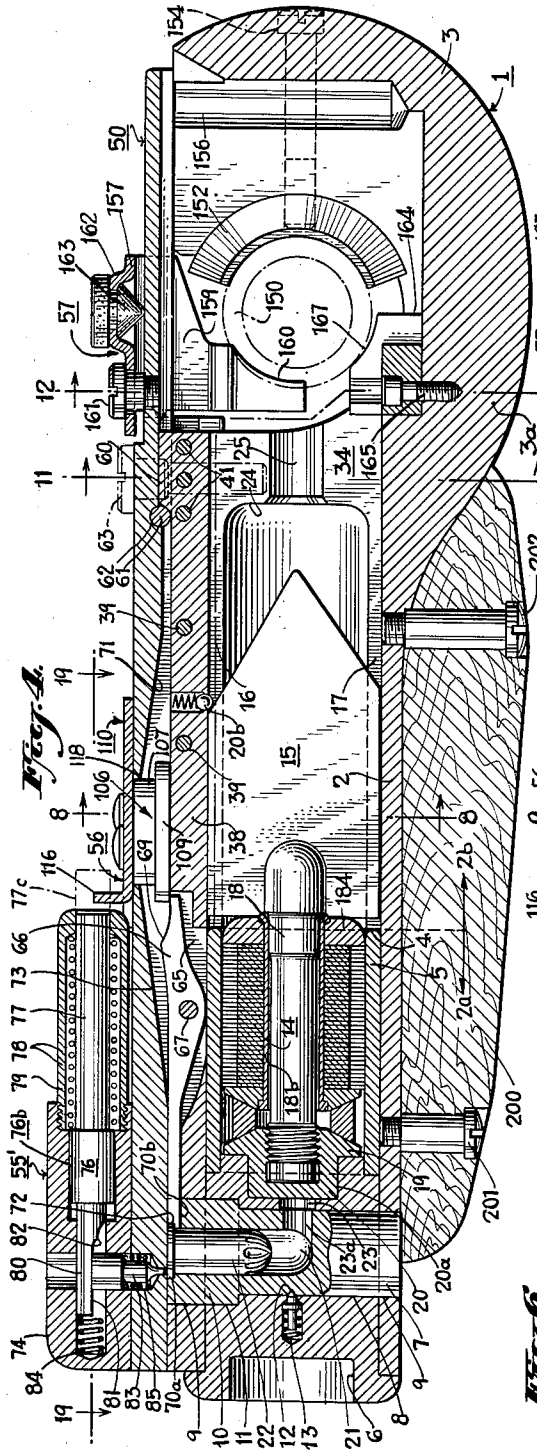


Fig. 4.

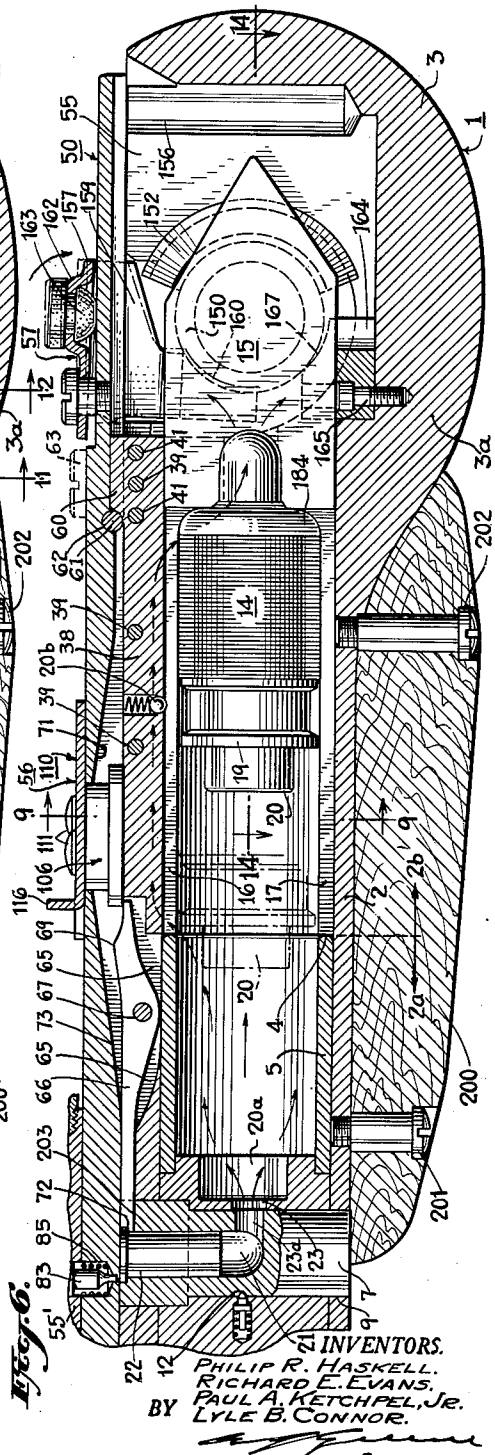


Fig. 6.

INVENTORS.
PHILIP R. HASKELL.
RICHARD E. EVANS.
PAUL A. KETCHPEL, JR.
LYLE B. CONNOR.
BY
John H. Lewis Jr.
ATTORNEY.

March 13, 1962 P. R. HASKELL ET AL 3,024,530

CARTRIDGE-POWERED PISTON TYPE TOOL

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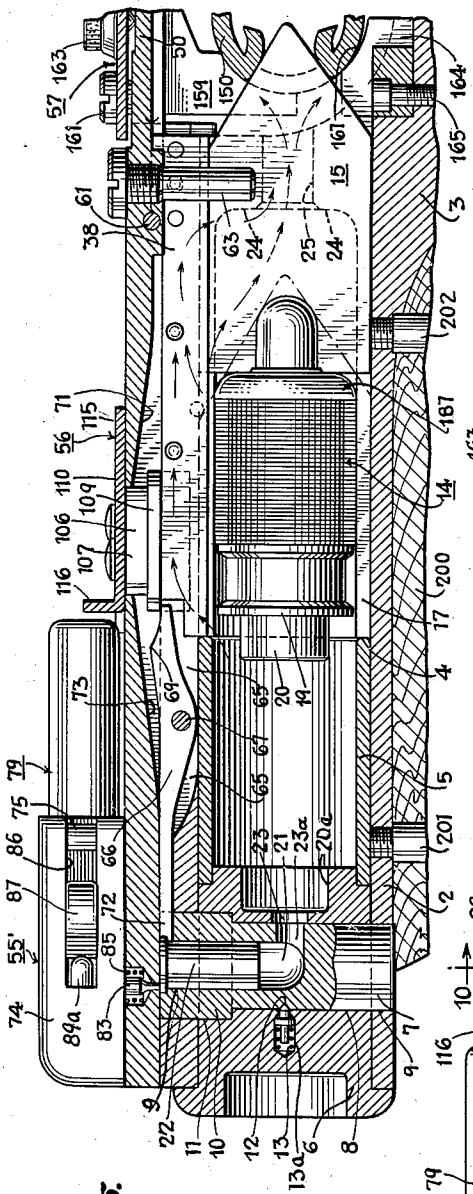


Fig. 5.

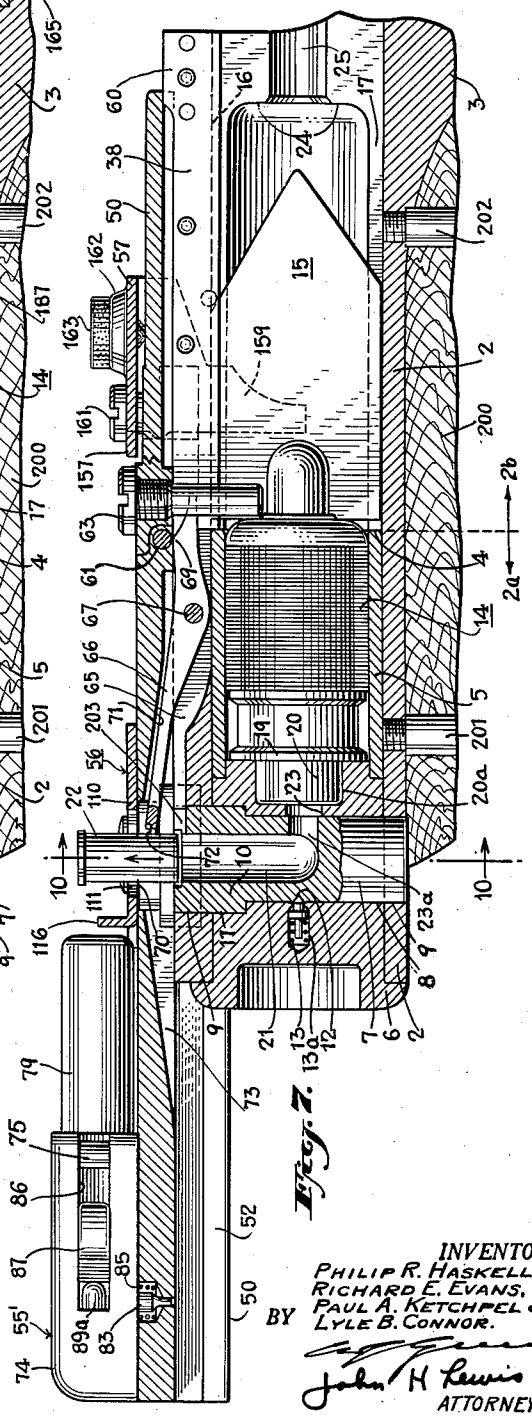


Fig. 7.

INVENTORS.
PHILIP R. HASKELL.
RICHARD E. EVANS,
PAUL A. KETCHPEL JR.
BY LYLE B. CONNOR.

John H Lewis Jr.
ATTORNEY.

March 13, 1962 P. R. HASKELL ET AL 3,024,530

CARTRIDGE-POWERED PISTON TYPE TOOL

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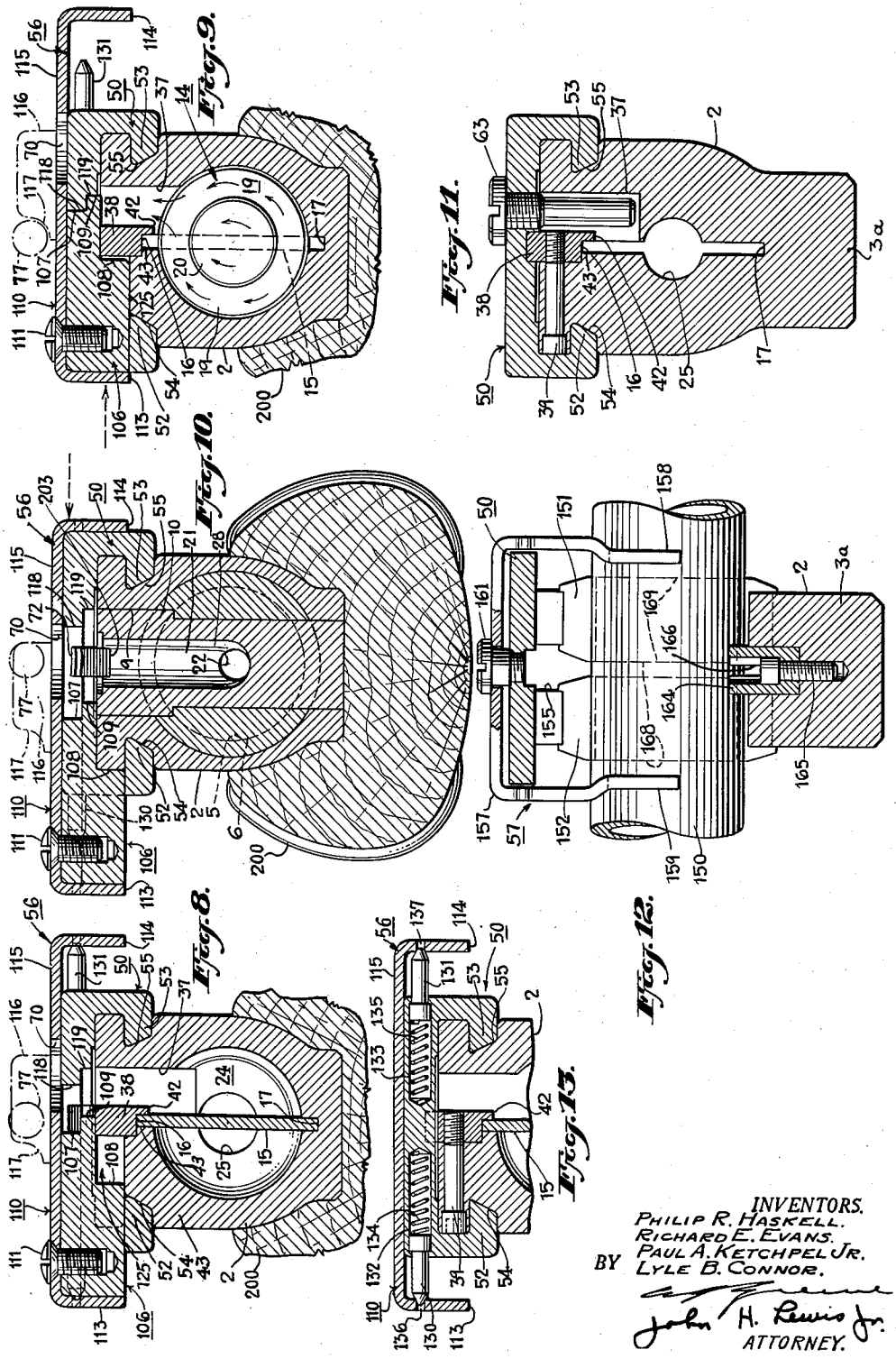


Fig. 9.

Fig. 11.

Fig. 10.

Fig. 12.

Fig. 8.

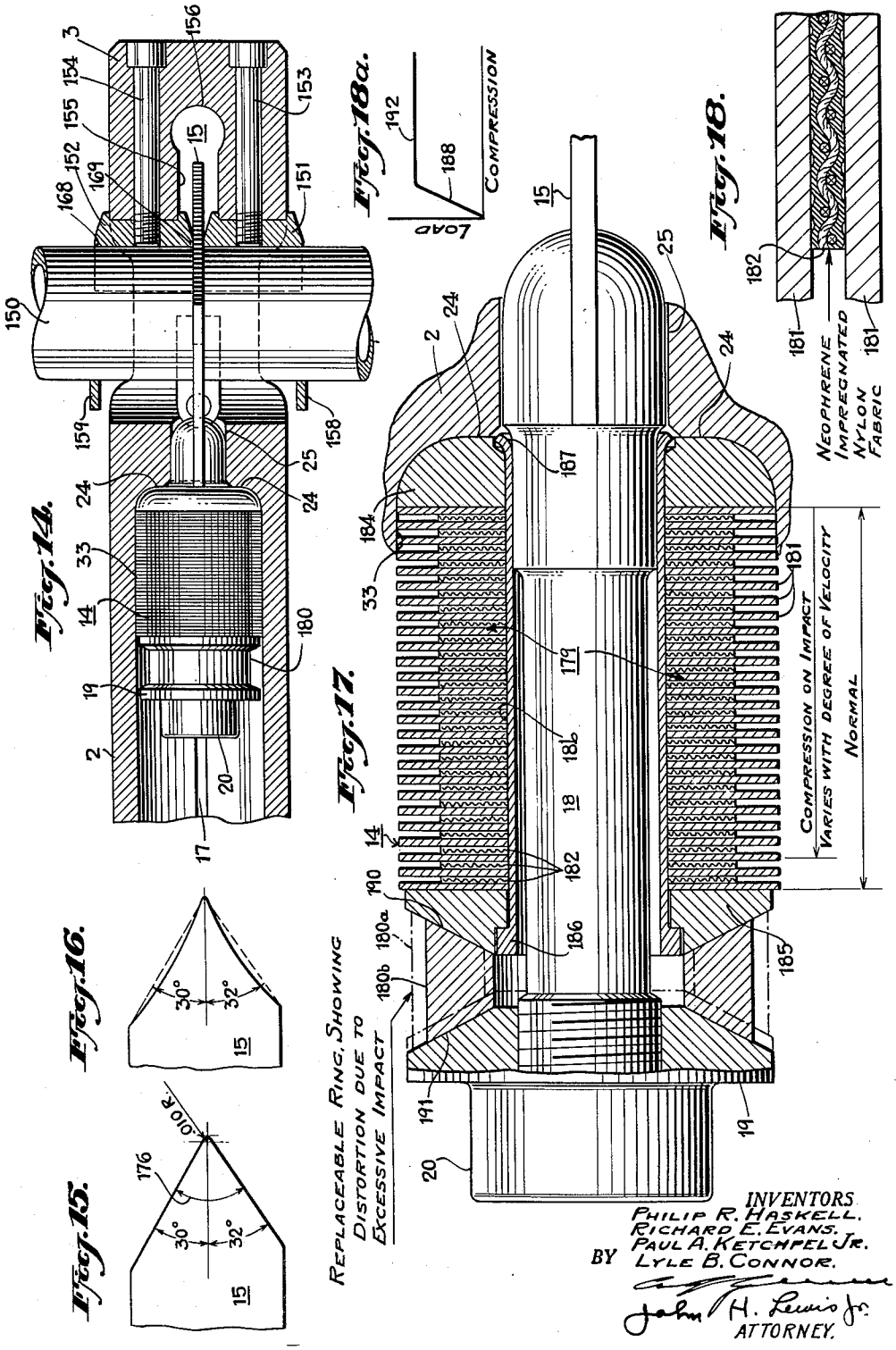
Fig. 13.

INVENTORS.
PHILIP R. HASKELL.
RICHARD E. EVANS.
PAUL A. KETCHPEL JR.
LYLE B. CONNOR.
BY John H. Lewis Jr.
ATTORNEY.

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CARTRIDGE-POWERED PISTON TYPE TOOL

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CARTRIDGE-POWERED PISTON TYPE TOOL

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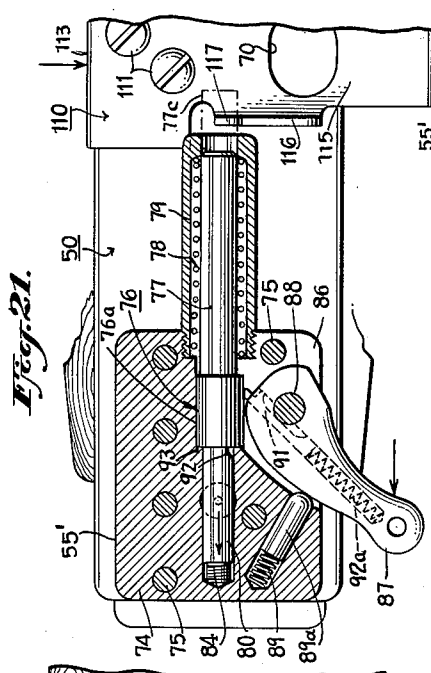


Fig. 21.

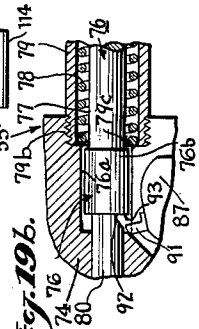


Fig. 19b.

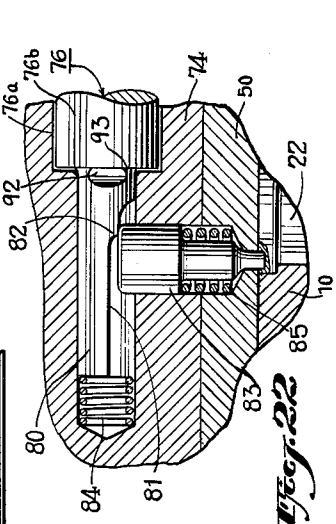


Fig. 22

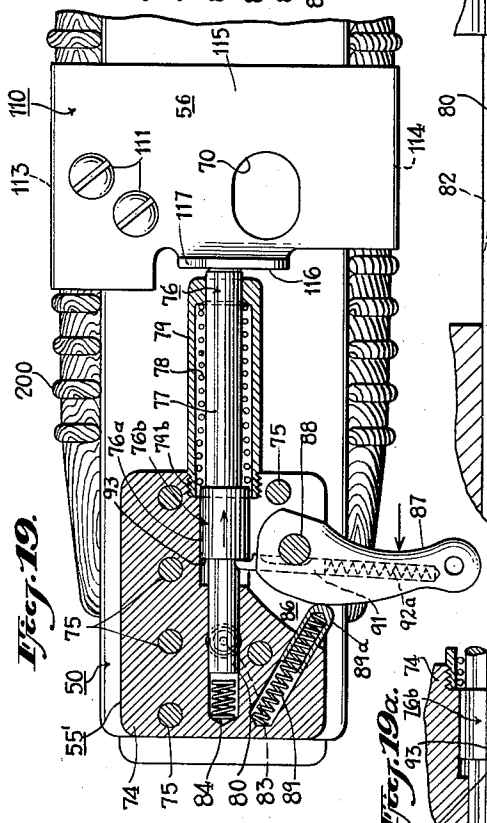


Fig. 19.

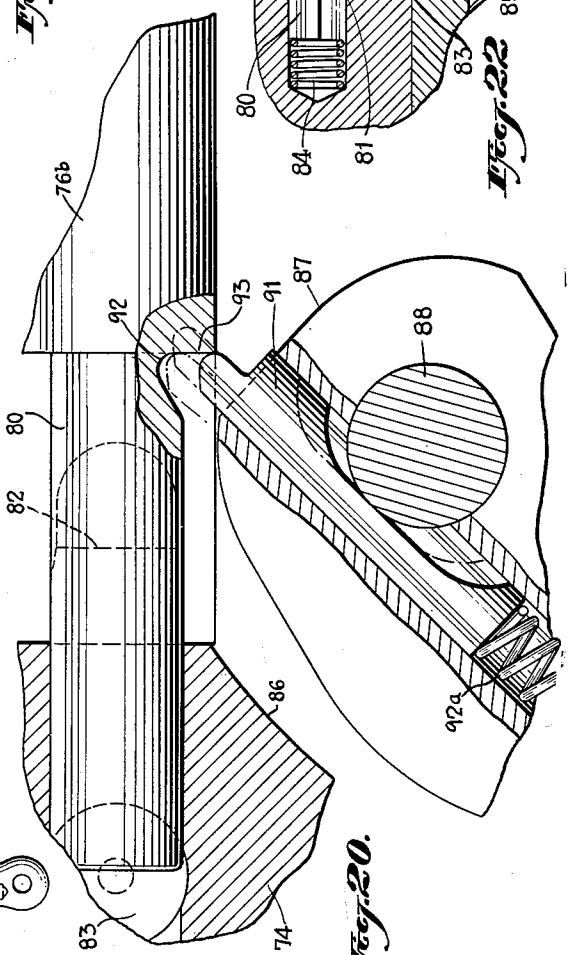


Fig. 20.

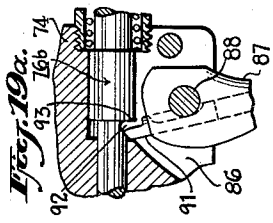


Fig. 19a.

INVENTORS.
PHILIP R. HASKELL.
RICHARD E. EVANS.
PAUL A. KETCHPEL, JR.
BY LYLE B. CONNOR.

John H. Lewis Jr.
ATTORNEY.

March 13, 1962 P. R. HASKELL ET AL 3,024,530

CARTRIDGE-POWERED PISTON TYPE TOOL

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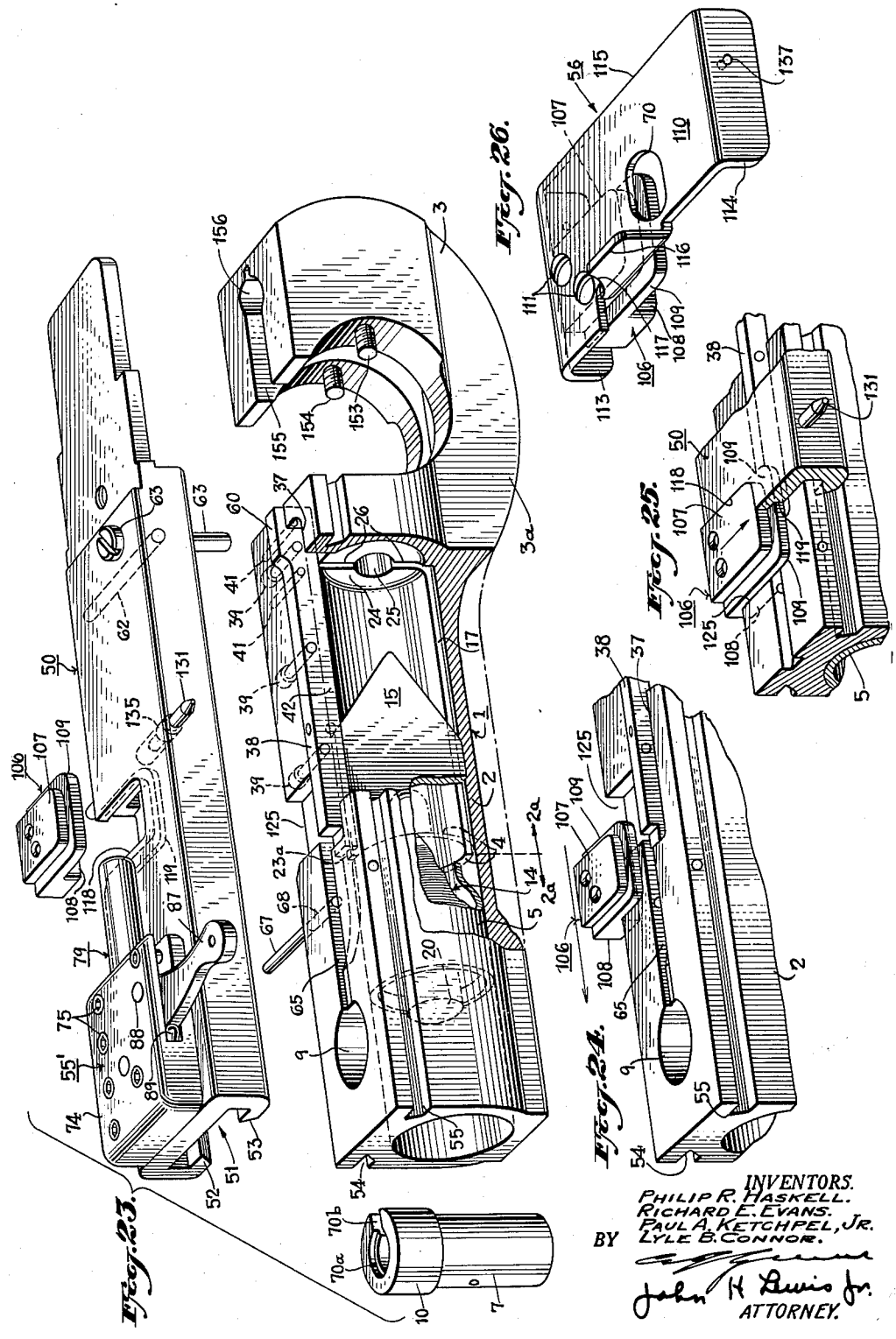


Fig. 23.

Fig. 24.

Fig. 25.

Fig. 26.

INVENTORS.
PHILIP R. HASKELL.
RICHARD E. EVANS.
PAUL A. KETCHPEL, JR.
LYLE B. CONNOR.
BY
John H. Lewis Jr.
ATTORNEY.

March 13, 1962 P. R. HASKELL ET AL 3,024,530

CARTRIDGE-POWERED PISTON TYPE TOOL

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Fig. 34.

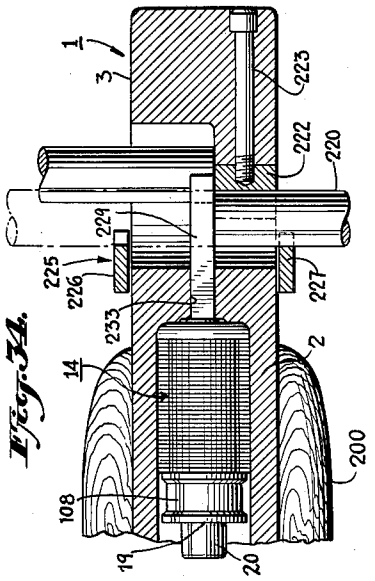


Fig. 30.

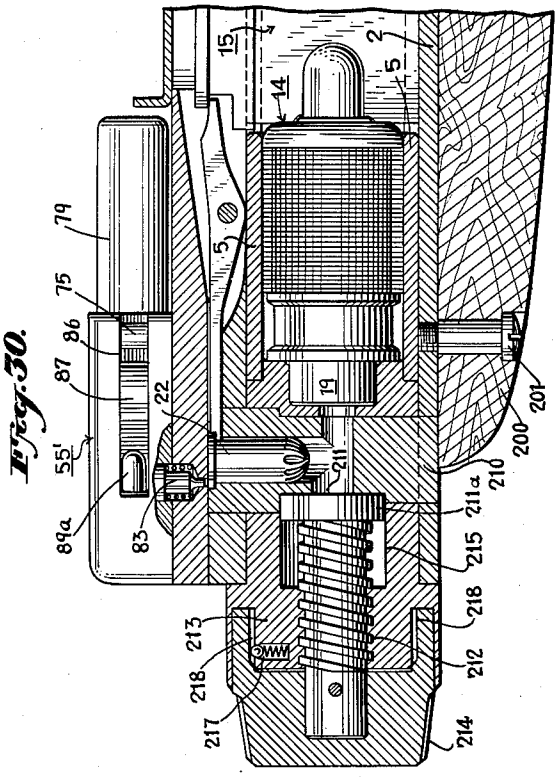


Fig. 33.

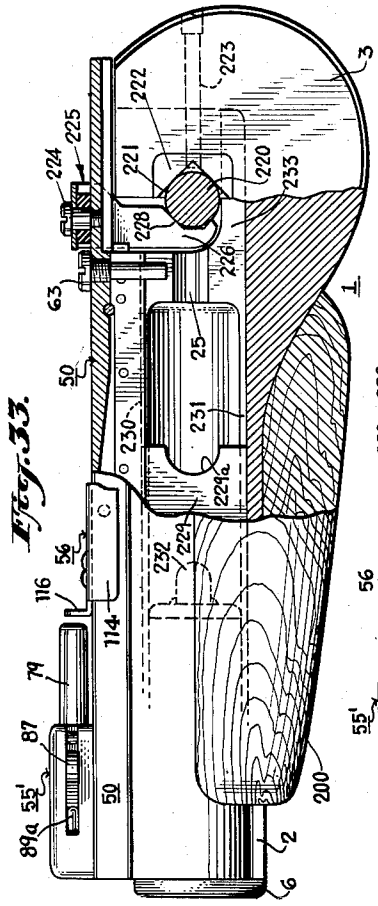


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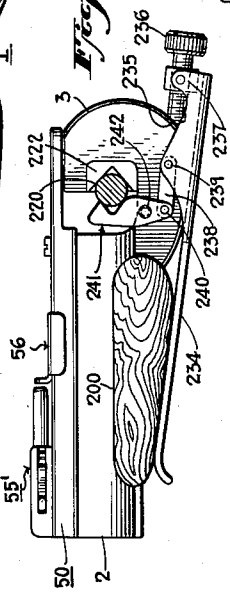


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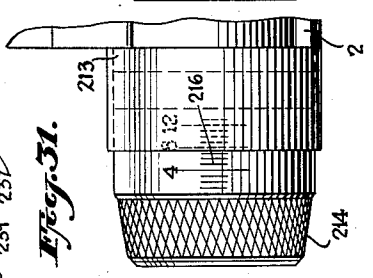
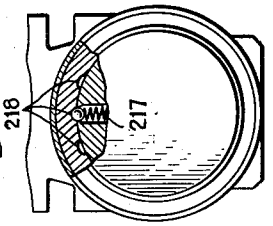


Fig. 32.



INVENTORS
PHILIP R. HASKELL.
RICHARD E. EVANS.
PAUL A. KETCHPEL, JR.
BY LYLE B. CONNOR.

John H. Lewis Jr.
ATTORNEY.

March 13, 1962 P. R. HASKELL ET AL 3,024,530

CARTRIDGE-POWERED PISTON TYPE TOOL

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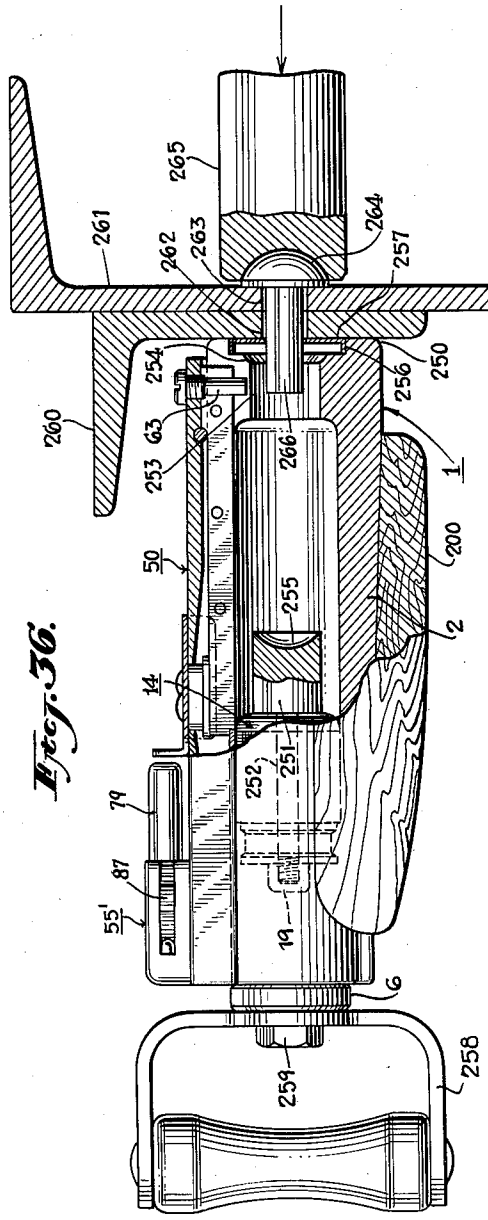


Fig. 36.

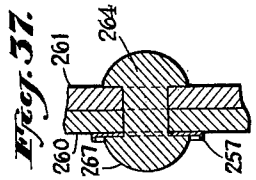


Fig. 37.

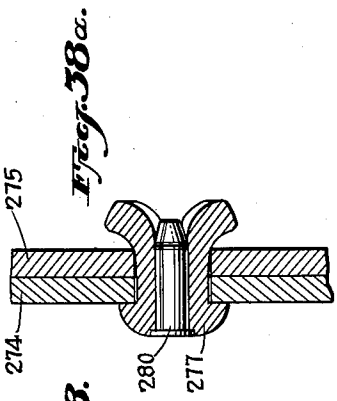


Fig. 38a.

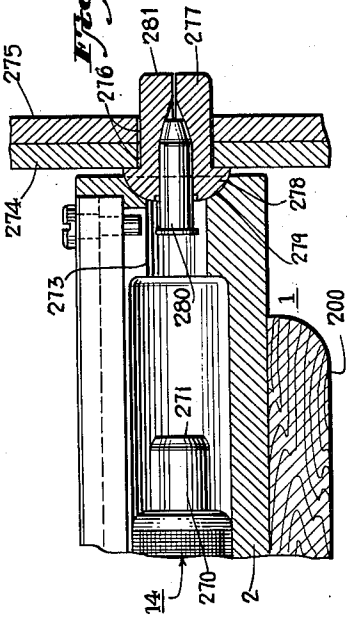


Fig. 38.

INVENTORS.
PHILIP R. HASKELL.
RICHARD E. EVANS.
PAUL A. KETCHPEL, JR.
BY LYLE B. CONNOR.

John H. Lewis Jr.
ATTORNEY

March 13, 1962 P. R. HASKELL ET AL 3,024,530

CARTRIDGE-POWERED PISTON TYPE TOOL

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Fig. 40.

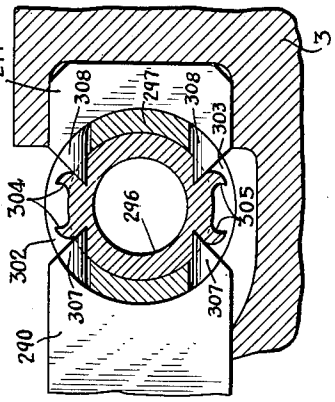


Fig. 42.

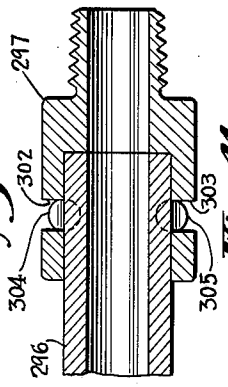


Fig. 41.

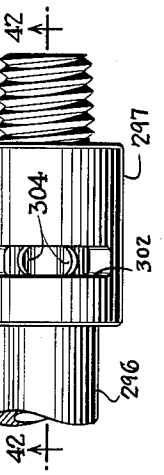


Fig. 39.

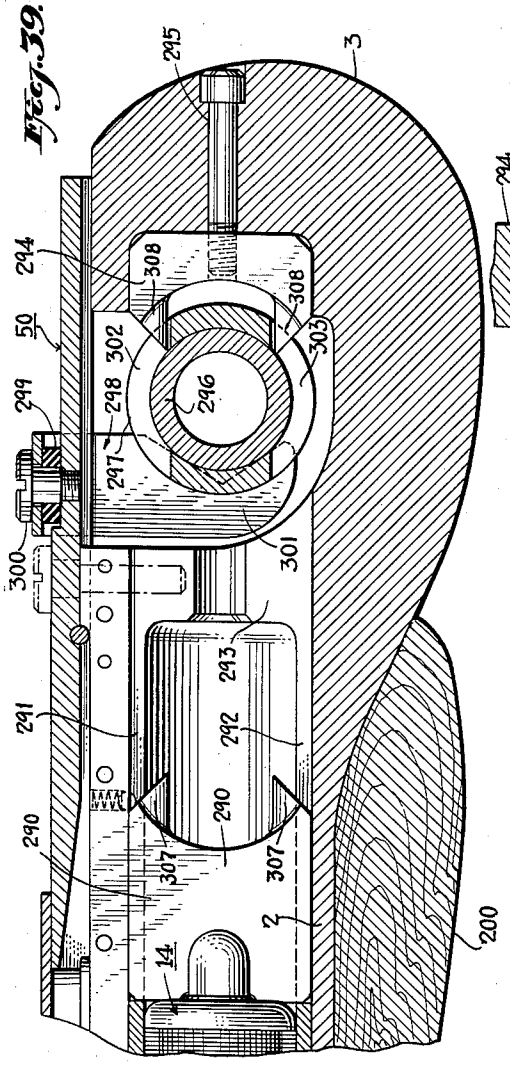


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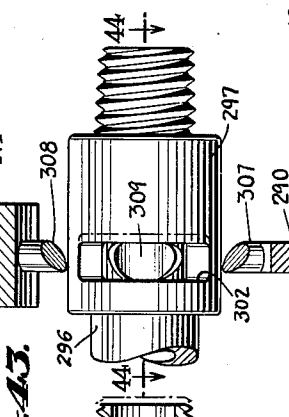


Fig. 44.

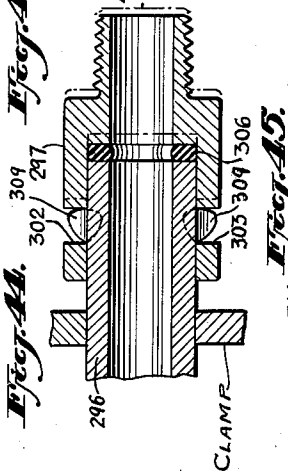
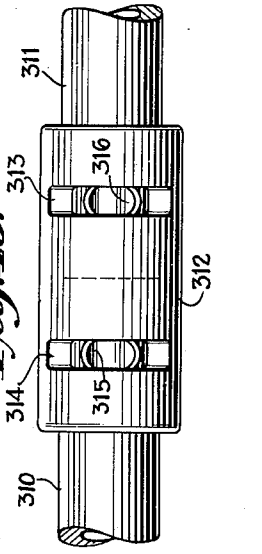


Fig. 45.



INVENTORS.
PHILIP R. HASKELL.
RICHARD E. EVANS.
PAUL A. KETCHPEL, JR.
BY LYLE B. CONNOR.

John H. Lewis Jr.
ATTORNEY.

March 13, 1962 P. R. HASKELL ET AL 3,024,530

CARTRIDGE-POWERED PISTON TYPE TOOL

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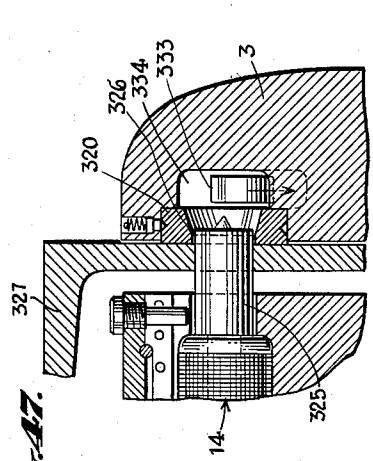


Fig. 47.

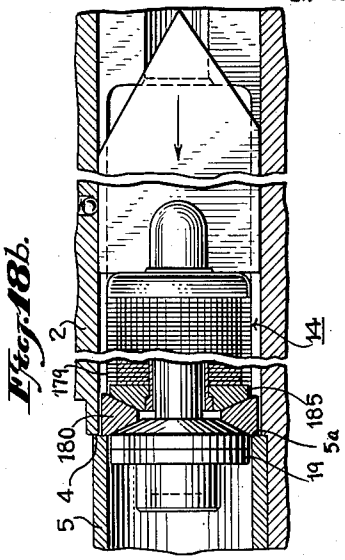


Fig. 18b.

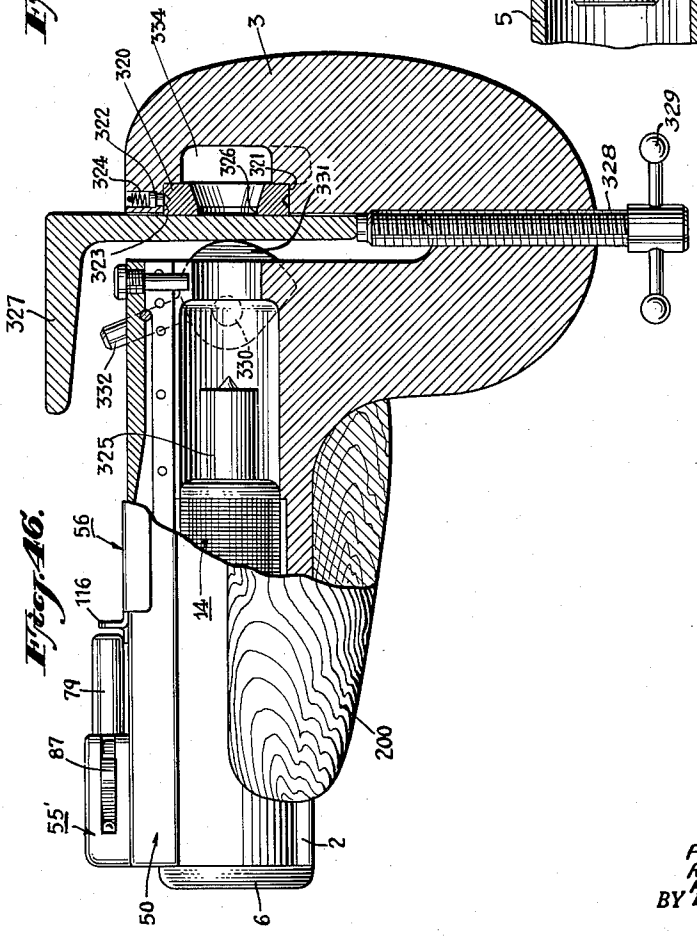


Fig. 46.

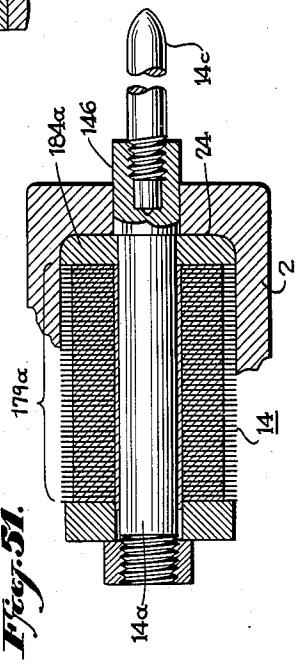


Fig. 51.

INVENTORS.
PHILIP R. HASKELL.
RICHARD E. EVANS.
PAUL A. KETCHPEL, JR.
BY LYLE B. CONNOR.

John H Reuniss Jr.
ATTORNEY.

March 13, 1962 P. R. HASKELL ET AL 3,024,530

CARTRIDGE-POWERED PISTON TYPE TOOL

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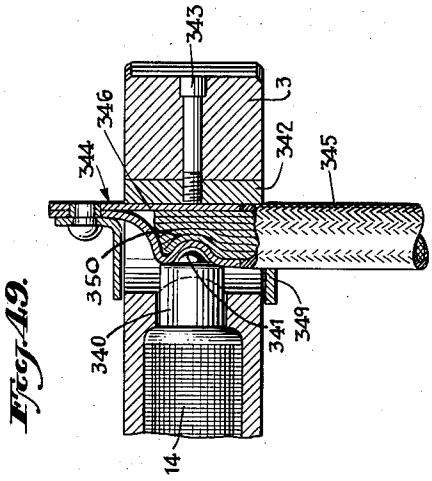


Fig. 49.

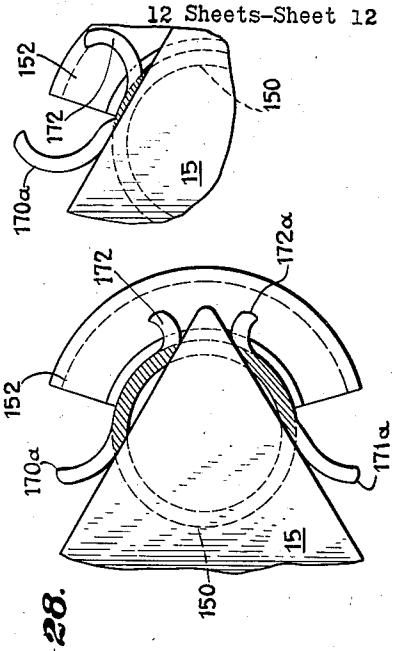


Fig. 29.

Fig. 28.

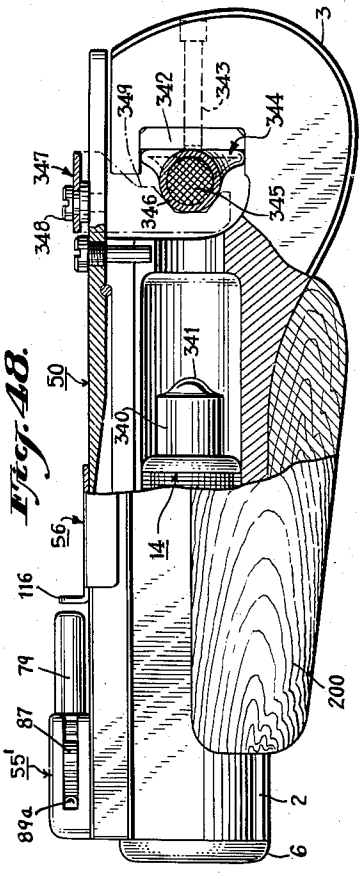


Fig. 48.

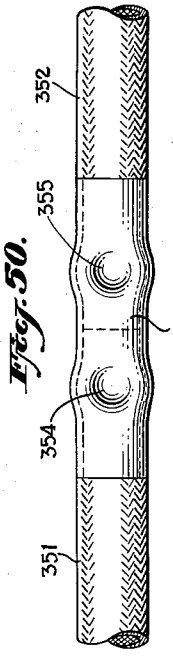


Fig. 50.

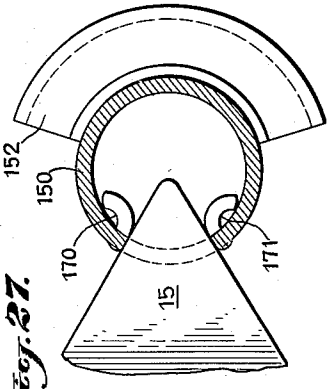


Fig. 27.

INVENTORS.
PHILIP R. HASKELL.
RICHARD E. EVANS.
PAUL A. KETCHPEL, JR.
BY LYLE B. CONNOR.

John H. Lewis Jr.
ATTORNEY.

United States Patent Office 3,024,530 Patented Mar. 13, 1962

3,024,530

CARTRIDGE-POWERED PISTON TYPE TOOL

Philip R. Haskell, Fairfield, Richard E. Evans, Southport, and Lyle B. Connor, Westport, Conn., and Paul A. Ketchpel, Jr., West Englewood, N.J., assignors to Remington Arms Company, Inc., Bridgeport, Conn., a corporation of Delaware

Filed May 10, 1955, Ser. No. 507,281
17 Claims. (Cl. 30—92)

This invention pertains to explosively actuated or cartridge powered tools, and provides a tool of this type of unique construction which is characterized by extreme compactness, lightness in weight and ease of manipulation with a minimum of effort, and which furthermore is substantialy foolproof.

In its various modifications the tool of the invention is adapted for performing a wide variety of work functions, such as the cutting of conduit, bar stock and heavy cable, etc., the punching of holes, riveting, the swaging of terminals or sleeves on electrical cables for terminating or uniting the same, the uniting of electrical conduit sections by means of an interposed coupling member, as well as the securing of threaded members on electrical conduit terminations, etc.

The tool of the invention comprises in its essentials and in accordance with a preferred modification, an elongated frame member of steel comprising a tubular or barrel section terminating at one end in a hook-like retainer arm of substantially C-shaped configuration for mounting a work piece to be operated upon. Within the barrel section is slidably displaceable a piston which mounts on its forward end a work tool, such as a cutter blade, hole puncher, cable swager, riveting plunger, etc. The tubular section of the frame is of reduced aperture at its muzzle end to provide a shouldered impact face for arresting forward motion of the piston thereat. The muzzle end is, in addition, appropriately apertured for passage of the work tool therethrough to work engaging position with a work piece held in the retainer arm.

The breech end of the barrel section is closed by means of a barrel plug insertable therein, this plug having a flanged head which overlies the end of the frame thus to prevent incorrect or wrong-end-to assembly. The breech end of the frame as well as the barrel plug are transversely apertured and counterbored for insertion of a relatively massive cartridge chamber plug having an enlarged head which seats in the counterbore, thus again preventing incorrect assembly. This chamber plug contains a bore extending axially through the head for insertion of a cartridge, whereby the tool is cartridge chambered substantially at right angles to the barrel axis, a feature which permits of substantially shortening the effective length of the tool and eliminates the necessity for safety precautions such as are otherwise required in conventional constructions wherein the cartridge chamber is aligned with the barrel. The cartridge chamber has access to the barrel through a sidewall outlet and an aligned bore extending through the end of the barrel plug.

In the firing position the piston is disposed at the breech end of the frame barrel and against the barrel plug in a relatively short barrel sleeve which rests against a shoulder of the frame barrel and is held in position by the barrel plug.

Mounted adjacent the cartridge chamber opening is an elongated ejector, one end of which engages a slot in the upper face of the cartridge chamber plug for assuring proper alignment of the outlet passage thereof with the aligned barrel plug outlet passage aforesaid.

This ejector is pivotally mounted on the frame and pivots between cartridge seating and ejecting positions.

The tubular section of the frame is longitudinally slotted along its upper outer sidewalls for slidable reception of a cover having downwardly extending and turned in sidewalls for lockingly engaging these grooves against the explosive action of the tool when fired. This cover, when appropriately assembled on the frame as noted below, is longitudinally displaceable between loading and firing stations. It mounts on its breech end a firing unit including a firing pin which, in the firing position of the cover, is disposed in alignment wtih the rim of a cartridge inserted in the cartridge chamber for firing the same. The firing unit also includes a firing hammer or bolt which is displaceable longitudinally of the cover. Mounted on the cover adjacent this hammer is a safety locking device, which takes the form of a cross slide member, and which prevents firing of the firing unit except when the cover is adjusted to the firing station and the cross slide adjusted thereat to a firing positon. To this end, the cross slide includes a cam member which, when the cover is positioned at the firing station, is adapted to enter a cutout in the frame extending transversely inward from one side thereof. The cross slide is provided with a resilient plunger actuated centering mechanism which causes the cross slide cam partially to enter this cutout with the cover positioned at the firing station, thereby to prevent longitudinal displacement of the cover with respect to the frame. The cross slide mounts an upstanding shield which is normally positioned in the path of traverse of the firing bolt and thus prevents actuation of the firing unit. With the cover positioned at the firing station as aforesaid, the cross slide may be transversely adjusted to one limiting positon wherein the cam thereon enters the frame cutout to the maximum depth, and in this position the shield is displaced from the path of the firing bolt whereby the firing unit may be actuated. In the opposite limiting position of the cross slide the cam thereon disengages the frame cutout whereby the cover may be actuated to the loading position.

Threaded through the cover is a bolt which extends through an elongated slot in the upper face of the frame, which bolt is positioned in the path of traverse of the piston, and serves to position the piston at the breech end of the frame barrel when the cover is actuated from its firing station to its loading station. At the firing station position of the cover, however, this bolt is longitudinally positioned beyond the impact face at the muzzle end of the frame and thus does not interfere with the forward traverse of the piston to the work piece actuating position. For removing the cover from the frame this bolt is unscrewed and withdrawn, whereby the cover may be slid endwise off the frame as a first step in the takedown operation.

Mounted on the under side of the cover is a cross pin which, on actuation of the cover from the firing to the loading station, engages a concave camming face on the cartridge ejector and thus tilts it to the cartridge ejecting position. The cover and cross slide are also provided with an appropriate aperture which, with the cover positioned at the loading station, exposes the cartridge chamber bore for cartridge insertion and ejection purposes. The under side of the cover is also provided with an inclined ramp which, on displacement of the cover from the loading to the firing station, seats the cartridge in the chamber cavity and also seats the ejector end of the ejector in the cartridge chamber plug slot above mentioned, thus assuring that the unit is in proper condition for firing when the cover is adjusted to the firing station.

The C-shaped retainer arm of the frame mounts appropriate bushings or dies for reception of a work piece, which is clamped in position with the cover adjusted to the firing station by means of a cooperating clamping device resiliently mounted on the muzzle end of the cover. Also the cover is of such length that when adjusted to the firing station, it covers the open C of the retainer arm and thus shields the operator against chips, etc., ejected from the workpiece on engagement of the work tool therewith.

The under side of the frame mounts an appropriate handle for gripping the tool in one hand while the other hand is employed to manipulate the cross slide safety device and also actuate the trigger of the firing unit.

In addition to the novel features of construction and operation of the tool above discussed, it embodies various other unique features which will be but briefly touched upon at this point and elaborated upon hereinafter.

One of the most important of these is a novel shock absorbing assembly mounted on the piston for preventing injury to the equipment on impact of the piston with the impact face of the frame, particularly if the tool is fired inadvertently with no workpiece mounted in the retainer arm. This shock absorbing mechanism comprises an elastically deformable member which is adapted to absorb the excess kinetic energy for stopping the piston at the impact face after the work tool has performed its function. The other is a plastically deformable member for absorbing such excess kinetic energy as cannot be taken up by the elastically deformable unit, and which comes into play particularly if the tool is fired with no work piece mounted in the retainer arm. These two units are mounted in axial alignment on the piston so that the elastically deformable shock absorber absorbs the initial impact to its maximum extent whereupon the residue is absorbed by the plastically deformable component. The elastically deformable unit is of laminated construction and in its preferred embodiment, comprises an axially aligned assemblage of metal rings, preferably of steel, interleaved with which are other rings formed of fibrous material impregnated with an elastic polymer, preferably woven nylon fabric impregnated with neoprene.

Another novel feature resides in the termination of the rear end of the piston in a protuberance of relatively small bore as compared to the piston proper or barrel which protuberance seats, in the firing position, in a bore of substantially corresponding diameter formed in the inner end of the barrel plug and which has access to the cartridge chamber through the outlet apertures of smaller bore above mentioned. This relatively small bore in which the protuberant piston terminus seats, is of such diameter and length as to assure complete burning of the powder charge before this piston protuberance passes out of the conforming barrel plug bore, and thus assures that the powder charge will not "snuff out."

Having thus described the invention in general terms, reference will now be had for a more detailed description of the construction and additional novel features of the invention, to the accompanying drawings wherein:

FIGURE 1 is a top plan view of a tool in accordance with one modification of the invention adapted for the cutting of conduit; while FIGURE 2 is a similar view with the cover and appurtenant components removed. FIGURE 3 is a fragmentary plan view of the FIGURE 2 showing, with certain components added, as explained below.

FIGURE 4 is a longitudinal sectional elevation through the entire tool assembly as taken at **4—4** of FIGURE 1, and showing the tool in condition for firing.

FIGURES 5 and 6 are views similar to FIGURE 4, but subsequent to firing and showing the advance of the piston and cutter assembly in successive stages to the cutting position.

FIGURE 7 is a partial showing, similar to FIGURE 4, but illustrating the tool in the cartridge ejecting or loading condition.

FIGURES 8–12, inc., are transverse sectional elevations as taken respectively at **8—8** of FIGURES 1 and 4, **9—9** of FIGURE 6, **10—10** of FIGURE 7, **11—11** of FIGURE 4 and **12—12** of FIGURE 4.

FIGURE 13 is a sectional detail as taken at **13—13** of FIGURE 1.

FIGURE 14 is a fragmentary sectional plan view as taken at **14—14** of FIGURE 6.

FIGURES 15 and 16 are fragmentary views in side elevation of the cutting element, showing various preferred profile configurations thereof.

FIGURE 17 is an enlarged longitudinal sectional view of the piston assembly showing in detail the shock absorbing and safety feature constructions; while FIGURE 18 is an enlarged fragmentary sectional detail showing two of the steel shim laminae and interposed neoprene-impregnated nylon fabric laminae of the shock absorbing assembly of FIGURE 17.

FIGURE 18*a* is a graph idealizing the load-compression characteristics of the shock absorbing constructions of the FIGURES 17 and 18 showings.

FIGURE 18*b* is a fragmentary, axial sectional elevation of a modified form of the piston and frame assembly illustrating the action of the safety feature of the shock absorbing assembly in disabling the tool when fired in the absence of a workpiece.

FIGURE 19 is a sectional plan view of the firing unit in the firing position as taken at **19—19** of FIGURE 4. FIGURES 19*a* and 19*b* are enlarged, fragmentary sectional details of the FIGURE 19 showing. FIGURE 20 is an enlarged sectional detail similar to a portion of FIGURE 19, but showing the positioning of the firing mchanism just prior to release of the firing bolt or hammer. FIGURE 21 is a view similar to FIGURE 20 but showing the positioning of the mechanism immediately following the firing. FIGURE 22 is an enlarged longitudinal sectional detail showing actuation of the firing pin by the hammer at the instant of firing.

FIGURE 23 is an exploded perspective view of certain components of the tool assembly, namely, the frame and piston assembly, frame cover, cross slide cam and cartridge chamber members, with a portion of the frame broken away to show the interior construction and assembly.

FIGURE 24 is a fragmentary detail in perspective showing a portion of the frame and the cross slide cam in one position of adjustment; while FIGURE 25 is a somewhat similar view showing the cross slide cam in a second position of adjustment on the frame, this view also showing a portion of the cross slide cover.

FIGURE 26 is a perspective view of the cross slide and cross slide cover assembly.

FIGURES 27–29, inc., are transverse sectional details illustrating the cutting and shearing action of the cutter blade in severing the conduit.

FIGURE 30 is a longitudinal sectional elevation of the breech end of the tool, similar to FIGURE 4, but showing a modification of the cartridge chamber for varying the explosive action from a standard cartridge.

FIGURE 31 is a detail in side elevation of the adjusting knob shown in section in FIGURE 30; while FIGURE 32 is an end view of the adjusting knob of FIGURE 31 with a portion broken away to illustrate suitable detent indexing means for positioning the knob at various settings.

FIGURE 33 is a side elevation of a modification of the invention employed for the shearing of bar stock. FIGURE 34 is a sectional plan view of the FIGURE 33 showing, with the piston and bar cutter shear advanced to the cutting position. FIGURE 35 is a side elevation of a modification of the FIGURE 33 showing, and

illustrating a novel bar stock clamping device applicable thereto.

FIGURE 36 is a side elevation, partly in section, of a modification of the invention adapted for riveting work components together; while FIGURE 37 is a sectional detail of the resulting workpiece as riveted. FIGURE 38 is a fragmentary showing in axial sectional elevation of a further modification of the FIGURE 36 device adapted for the joining of workpieces by means of so-called "Cherry" type riveting; while FIGURE 38*a* shows in sectional elevation the completed effect of such riveting procedure on the work piece.

FIGURE 39 is a fragmentary longitudinal sectional elevation of a staking tool modification of the invention for staking a threaded pipe termination onto the end of a pipe section; while FIGURE 40 is a view in transverse section showing the completed staking operation. FIGURE 41 is an end plan view corresponding to the transverse section of FIGURE 40; while FIGURE 42 is an axial sectional elevation as taken at 42—42 of FIGURE 41.

FIGURE 43 is a plan view, partly in section, showing a modification of the FIGURE 39 staking operation for staking a threaded terminus to a pipe terminus with an interposed resilient gasket; while FIGURE 44 is a sectional plan view of the same as taken at 44—44 of FIGURE 43. FIGURE 45 is a plan view illustrating the joining of two conduit pipe ends with a coupling section by employment of the staking modification of the invention illustrated in FIGURE 39.

FIGURE 46 is a view in side elevation and partly in section of a modification of the invention adapted for punching holes in a work piece; while FIGURE 47 is a detail in sectional elevation showing the completion of the operation.

FIGURE 48 is a view in side elevation and partly in section of a further modification of the invention employed for swaging a terminal lug onto the end of an electrical cable; while FIGURE 49 is a sectional plan view of the completed operation. FIGURE 50 is a plan view illustrating the application of the FIGURE 48 modification to the joining of two cable ends by a coupling sleeve by employment of a double swaging operation.

FIGURE 51 is a fragmentary axial sectional elevation of a further modification of the invention, adapted for the driving of studs and related fastening devices.

Referring to FIGS. 1–29, inc., of the drawings, the conduit-cutting modification of the invention shown comprises a frame, identified generally by numeral **1**, consisting of a tubular frame portion **2** extending from the breech end **2***a* at the left to the muzzle end **2***b* at the right, and a C-frame extension (FIGS. 4 and 23) comprising a work support **3** in general longitudinal alignment with the frame portion **2** and connected therewith by a curved shank **3***a*. The breech end of the frame portion is of slightly enlarged bore as compared to the muzzle end of the frame portion **2** and thus provides a shoulder at **4**, FIGS. 4 and 23, against which a relatively short sleeve barrel **5** is held by means of a barrel plug **6**, FIG. 4, inserted in the breech end of the frame. In a modified form of the construction shown in FIG. 18*b*, the forward end of the barrel sleeve **5** supplies a forwardly facing shoulder **5***a* for a purpose to be described below with reference to said FIG. 18*b*. The barrel plug is locked in the position shown by a cylindrical cartridge chamber plug **7**, which extends transversely of the barrel axis through suitable holes **8**, **9** drilled in the barrel plug **6** and the breech end **2***a* of the frame portion **2**, respectively. The cartridge chamber plug **7** is provided with an enlarged head **10** which seats in a counterbore **11** of the barrel plug, thus to maintain the assembly locked in position as shown in FIGS. 4–7.

The mouth of the chamber plug is radially slotted to receive an ejector (to be described), and to locate chamber plug **7** in proper longitudinal and radial position in the bores **8**, **9**, the cylindrical wall of the plug is notched for reception of a detent pin **12**, backed by a small compression spring **13**, mounted in an axial bore **13***a* of the barrel plug **6**.

In the firing position shown in FIG. 4, a piston **14** is slidably disposed in the sleeve barrel **5**, and to which is secured a cutter blade **15** positioned in advance of the piston in the frame portion of smaller inside diameter. The cutter blade is slidable in grooves **16**, **17** extending along the upper and lower portions of the frame barrel, these grooves being formed as explained below.

The cutter assembly **15** shown as a cutter blade is secured to or formed integral with a shank **18**, which extends through a central sleeve member **18***b* of the piston **14** and is secured to the piston by means of a piston cap **19** threaded onto the breech end of the shank **18**. This piston and cutter assembly will be described more in detail, infra.

For purposes above noted, to be explained in detail below, and as shown in FIG. 4, the breech end of the piston cap **19** terminates in a protuberant extension **20** of considerably smaller diameter than the piston **14**, which extension in the action or firing position, rests in a conforming bore **20***a* drilled in the inner end of the barrel plug **6**.

Also in the action or firing position of FIG. 4, the piston and cutter blade assembly **14**, **15**, is resiliently held in place by means of a resiliently mounted detent **20***b* which engages the upper edge of the cutter blade as shown.

The cartridge chamber plug **7** has formed in the upper portion thereof a bore **21** for insertion of a blank cartridge, as at **22**, the cavity below the cartridge forming an explosion chamber which has access through aligned openings in the sidewall of the chamber plug and the forward end of the barrel plug, as at **23***a*, **23**, to the bore **20***a* of the barrel plug.

Thus when the cartridge is fired, the piston and cutter assembly **14**, **15**, is impelled progressively forward as illustrated in FIGS. 5 and 6, until the pointed end of the cutter blade has advanced to the position shown in FIG. 6 to sever the conduit as discussed, post. The piston and cutter assembly is thereupon brought to rest by engagement of the forward end of the piston **14** with a shouldered impact face **24**, FIGS. 2, 4, 7, and 23, of conforming configuration formed at the muzzle end **2***b* of the tubular frame section **2**, at which the bore is tapered to an outlet passage **25** of relatively small bore through which the explosion gases escape as explained below. The muzzle end of the frame is also vertically slotted, as at **26**, FIG. 23, to permit advance therethrough of the cutter blade to the conduit cutting position of FIG. 6.

The tubular frame section **2** is longitudinally slotted through its upper surface as at **37**, FIGS. 2, 8, 9, 11 and 23, this slot being offset somewhat from the axis of the frame, as shown. Mounted in this slot and partially closing the same is an insert member **38**, FIGS. 3, 4, 8, 9, 11 and 23, which is positioned in engagement with one side of the slot **37** as shown. This insert member is secured to the frame by means of screws as at **39**, FIGS. 3, 11 and 23, which extend through holes **40**, FIG. 2, in the sidewall of frame **2** and into threaded engagement with the insert member **38**, thereby clamping the insert member to the frame. For additional strength the screws **39** are supplemented by dowel pins **41**, which also extend as shown in FIGS. 3 and 23, through the sidewall of the frame section **2** and into suitable apertures provided in the insert member **38**, these dowels frictionally engaging the frame and insert member in a tight fit.

The insert member **38** is of substantially rectangular cross section, as shown in FIG. 8, except for a depending flange **42**, whereby the insert and the oppositely disposed surface portion **43** of the frame **2** provide a longitudinally extending grooved recess **16** in which the upper edge of the cutter blade **15** is slidably guided. Diametrically op-

posite to the grooved recess **16** thus provided, there is also machined in the frame **2** a corresponding groove **17**, for slidably guiding the lower edge of the cutter blade **15**.

As most clearly shown in FIG. 23, the frame 1 is provided with a cover or carriage **50** having in end view, as at **51**, a relatively flat C-shaped configuration, with turned in lower lateral edges, as at **52, 53**. The frame section **2** is correspondingly grooved along the upper edges of its opposite outer sidewalls, as at **54, 55**, whereby the cover may be slid endwise onto the frame in vertically locking engagement therewith, as shown in transverse section in FIGS. 8–10.

Mounted on the breech end of the cover is the firing unit **55'**, FIGS. 1 and 4. Mounted adjacent thereto is the cross slide protective device **56** which is transversely adjustable to locking, ejecting and firing positions, and which prevents firing except when adjusted to the position last mentioned. Resiliently mounted on the muzzle end of the cover is a clamping device **57** which clamps the conduit to be cut in the C terminus **3** of the frame when the cover is longitudinally positioned with respect to the frame as shown in FIG. 4.

For limiting the forward displacement of the cover **50** with respect to the frame **1**, the insert **38** is provided with a raised portion or shoulder **60** at the muzzle end of the frame section **2**, FIGS. 4 and 23. When the cover is advanced to the position of FIG. 4, this shoulder is engaged by a pin **61** extending transversely along the under side of the cover **50**, and mounted in a bore **62**, FIGS. 1 and 23, drilled through the sidewalls of the cover.

For returning the piston **14** from the impact face **24** of the frame barrel **2**, against which the piston rests after firing as above explained, a piston return bolt **63** is tapped vertically through the cover as shown in FIGS. 4, 5, 11 and 23, with the lower end of this bolt projecting into the slot **37** of the frame for a sufficient depth as shown in FIGS. 5, 7 and 11, to engage the piston as the cover **50** is displaced to the left from the firing position of FIG. 4, to the cartridge ejecting position of FIG. 7. It will be noted, referring to FIGS. 4 and 23, that the slot **37** extends at the muzzle end of the frame barrel **2**, beyond the piston impact face **24**, and is thus protected from impact by the piston even if the shoulder **24** is set back by repeated impact.

Referring more particularly to FIGS. 2, 6 and 23, a shallow axially extending slot **65**, is provided in the upper face of the frame section **2** near the breech end, in which is mounted an elongated cartridge ejector **66**, which pivots on a pin **67** retained in a transverse bore **68** of the frame. The ejector **66** is actuated by displacement of the cover **50** as follows: As the cover is retracted from the firing position of FIG. 4 to the cartridge ejecting position of FIG. 7, the pin **61** mounted on the under side of the cover, engages a concave cam face **69** of the ejector and rotates it clockwise to the canted position shown in FIG. 7, to eject the cartridge shell **22**, through an opening **70**, FIGS. 1 and 26, formed in the cover of the cross slide **56**. The under face of the frame cover **50** is provided with a sloping ram, as at **71**, to permit of this actuation of the ejector. With the cover in the position of FIG. 7, a new cartridge may be inserted through the cross slide opening **70**, until the rim thereof engages the cartridge ejector end **72** of the ejector, whereupon the frame cover **50** is returned to the position of FIG. 4. As the cover is thus moved into position a second sloping ramp provided on the opposite under side of the cover, as at **73**, engages the rim of the cartridge and seats it in the cartridge chamber cavity **28** with the shell rim flush with the upper edge of the cavity as shown in FIG. 4, while at the same time returning the ejector **66** to the cartridge seating position of FIG. 4 as the frame cover pin **61** rides off the cam face **69**. In order to provide for seating of both the cartridge shell **22** and the ejector **66** flush with the upper surface of the chamber plug **7**, this surface is peripherally recessed, as at **70***a* and radially slotted, as at **70***b*, FIGS. 4 and 23, appropriately to seat the shell rim and ejector, respectively.

Referring to FIGS. 4 and 19–22, inc., the firing unit **55'** comprises a housing **74**, secured to the frame cover **50**, by means of rivets **75**. The housing is drilled for axially displaceable reception of a firing bolt or hammer **76** having an intermediate portion **76***b* of enlarged diameter which is slidably displaceable in the frame bore **76***a* and from one end of which extends a hammer terminus **77** of smaller diameter, sleeved through a hammer spring **78**, housed in an open-ended sleeve-like retainer **79**, the inner end of which is threaded to the housing as at **79***b*.

As shown more particularly in FIG. 19*b*, the interior diameter of retainer **79** is of sufficiently enlarged diameter as compared to the bore **76***a* in which the enlarged portion **76***b* of the hammer slides, as to form a shoulder **79***c*, which retains the inner end of the hammer spring **78** when the hammer is in the normal positions of FIGS. 19 and 19*a*.

From the opposite end of the enlarged hammer portion **76***b*, there extends a second hammer terminus **80** having a flat under face **81**, FIG. 22, which terminates adjacent the enlarged hammer portion **76***b*, in a stepped cam face **82** for actuating a firing pin **83** in the manner illustrated in FIG. 22. Interposed in the housing bore between the end of the shank **80** and the bore terminus, is a relatively light spring **84** which is compressed in the firing movement of the hammer and thereafter returns the hammer to normal uncocked position with the shouldered end of hammer enlargement **76***b* contacting the spring **78** at the housing abutment **79***c*, as seen in FIG. 19*b*.

As shown in FIG. 4, the flat under face **81** of the terminus **80**, normally bears against the enlarged head of the firing pin **83**, which latter is positioned in a bore extending through the housing **74** and into the frame cover **50**. The lower end of the firing pin is of reduced diameter as shown and sleeves through a firing pin spring **85**, which is retained in position between the enlarged head of the firing pin and the reduced diameter base of the frame cover aperture, through which the tapered lower end of the firing pin extends into engagement with the rim of the cartridge **22**, when the tool is loaded in the manner illustrated in FIG. 4.

The housing **74** also mounts in a laterally extending slot **86** thereof, FIG. 19, a trigger **87**, which projects horizontally from the housing, FIGS. 19–21, inc., the trigger being pivotally mounted on a pin **88** extending through the housing **74** and spanning the slot **86**. The trigger is normally maintained in the position of FIG. 19*a*, by a compression spring **89**, FIG. 19 disposed in a bore of the housing, and bearing at its opposite ends against the housing and a cup-like retainer sleeve **89***a*, slidable within the housing bore, and the closed end of which bears against the trigger, as shown.

Slidably mounted in a bore of the trigger is a sear **91**, having a narrowed, finger-like upper end, which normally engages a notch **92** with a slight clearance as shown in FIG. 19*a*, this notch being formed in the side of the hammer terminus **80** adjacent the shoulder **93** of the enlarged diameter hammer or intermediate portion **76***b*. The sear is normally retained in the position of FIG. 19*a* by means of a compression spring **92***a*, disposed in a trigger bore beneath the lower end of the sear, as shown.

Referring to FIGS. 19–21, inc., as the trigger is gripped and rotated clockwise about its pivot point **88**, against the restoring action of the compression spring **89**, the upper end of the sear engages the hammer shoulder **93** and forces the hammer to the right against the compressive restoring action of the spring **78**, until the position assumed is about that shown in FIG. 20, at which point the hammer shoulder **93** overrides the rounded upper end of the sear and thus depresses the sear against the restoring action of the sear spring **92***a*, thereby permitting the bolt to be snapped smartly to the left by the restoring action

of the hammer spring **78**, in the manner shown in FIG. 21. As the hammer is thus snapped to the left, the flat under face **81** of the terminus **80** rides along the head of the firing pin until it is engaged by the camming surface **82**, which abruptly depresses the firing pin to fire the cartridge in the manner shown in FIG. 22. Overcarry of the hammer **76** compresses the hammer return spring **84**, as shown in FIG. 21, which immediately restores the hammer to the position of FIG. 19*a*, whereupon the momentarily compressed firing pin spring **85** returns the firing pin **83** to the position of FIG. 4, in engagement with the flat under face of the hammer terminus **80**.

Considering now the cross slide protective device **56**, the construction is best shown in the perspective views of FIGS. 23–26, inc., the assembly comprising a cross slide camming member shown generally at **106**, and embodying upper and lower substantially rectangular cam portions **107**, **108**, the upper portion **107** projecting beyond the lower portion **108**, and being provided with a flanged base **109**. Referring to FIG. 26, the cross slide assembly also includes a cross slide cover **110** which is secured to the cross slide by two screws **111** passing through apertures in the cover **110** and threading into the member **106**. The cover **110** comprises a relatively thin metal strip, the opposite ends of which are bent downwardly as at **113**, **114**, substantially at right angles to the main or body portion **115**. The cover is also cut to such shape as to provide a lug **116** integral with the left edge thereof, which lug is bent upwardly substantially at right angles to the body portion, to provide a shield which prevents actuation of the firing mechanism or unit **55'**, except when the cross slide is adjusted to the firing position, as explained below. To this latter end, the lug **116** is provided at one end with an arcuately shaped cutout portion **117**.

As shown in FIG. 23, the frame cover **50** has extending from one side thereof a substantially U-shaped cutout portion **118** for slidable reception of the cross slide camming member **106**. This cutout **118** is undercut along its lower edge as shown at **119**, to form guideways for the flanged portion **109** of the member **106**. The cutout **118** is located adjacent the exposed end of the hammer **76**, in the relative relationship illustrated in FIGS. 1, 4 and 23. In addition the frame section **2** has formed in its upper face, a substantially rectangular cutout portion **125**, which extends transversely inward from one sidewall thereof, to a depth corresponding to that of the lower camming portion **108** of the cross slide **106**, and which is adapted slidably to receive the same. The frame cutout **125** is located substantially the same distance from the breech end of the frame section **2** as is the cover cutout **118** with respect to the breech end of the cover **50**.

Thus when the frame cover **50** is longitudinally positioned on the frame section **2**, with the breech end of the cover aligned with the breech end of the frame, as shown in FIG. 4, the cover cutout **118** will be positioned above the frame cutout **125**, whereby the cross slide may be slid into the position shown in FIG. 25, in which the upper camming portion **107** penetrates the cover cutout **118** to the extreme depth thereof, and the lower camming portion penetrates the frame cutout **125** to the maximum depth thereof. In this position, therefore, the cross slide camming member **106** locks the frame cover **50** against longitudinal displacement with respect to the frame.

If now the cross slide camming member **106** is partially withdrawn until the inner surface of the lower cam portion **108** clears the sidewall of the frame section **2**, as shown in FIG. 24, the frame cover **50** may then be slid longitudinally with respect to the frame. In this position of partial withdrawal of the cross slide camming member **106**, the upper cam portion **107** is still slidably positioned partially within the cover cutout **118**.

The cross slide cover **110** is of such width as to permit these limiting transverse adjustments of the cross slide **106**, in the manner and for purposes best illustrated in the transverse sectional views of FIGS. 8–10, inc. In FIG. 9 the cross slide camming member and cover assembly **106**, **110**, is adjusted to the full depth of the frame cover and frame cutouts **118**, **125**, whereby the cross slide locks the frame cover **50** against longitudinal displacement with respect to the frame **2**. In FIG. 10, on the other hand, the cross slide and cover assembly is adjusted to the position that the lower cam portion **108** of the cross slide clears the sidewall of the frame section **2**, as shown, whereby the frame cover **50** may be longitudinally displaced with respect to the frame. It will be noted that the limiting transverse adjustment of the cross slide and cover assembly in this direction, is determined by the width of the cross slide cover **110**, this limiting adjustment being effected by engagement of the turned down end **114** of the cover with the right hand side of the frame cover **50**, in the manner illustrated in the FIG. 10 showing.

It will now be observed by reference to FIG. 9, that with the cross slide adjusted to the position of maximum penetration into the frame cover and frame cutouts **118**, **125**, the upstanding lug **116** on the cross slide cover has been laterally adjusted to a position such that its arcuate edge **117**, clears the path of traverse of the terminus portion **77** of the hammer **76**, whereby, referring now to FIG. 4, the firing unit **55'** may be actuated as a result of which actuation the terminus portion **77** of the hammer **76** is displaced from the shown position (full lines) to the position **77***c* (dot-dash lines).

On the other hand, when the cross slide camming member has been adjusted to its opposite limiting position as shown in FIG. 10 in which, as explained, the frame cover **50** may be longitudinally displaced with respect to the barrel **11**, the upstanding lug **116** on the cross slide cover is now positioned in the path of travel of the hammer **76**, so that the firing mechanism cannot be actuated. In the FIG. 10 position of the cross slide camming member, the frame cover **50** may be drawn back for shell ejection purposes in the manner and to the extent illustrated in FIG. 7.

Referring now to FIGS. 1 and 13, the frame cover **50** has mounted therein beneath the cross slide cover **110**, and extending from opposite sides of the frame cover, a pair of resiliently positioned plungers **130**, **131**, which tend to center the cross slide in the position shown in FIG. 13, and FIG. 8. To this end the frame cover **50** is provided with a pair of aligned holes **132**, **133**, in which are disposed, respectively, compression springs **134**, **135**, against which bear, respectively, the enlarged inner heads of the plungers **130**, **131**, these plungers being loosely swaged into the frame cover **50**, with their outer tapered ends seated in holes **136**, **137**, drilled through the depending ends **113**, **114**, of the slide cover. Thus the cross slide cover will tend to be restored to the position shown in FIG. 13, by actuation of the plungers described, if the cover is manually displaced in one direction or the other.

Accordingly, if the cross slide camming member has been manually adjusted to the FIG. 10 position for withdrawal of the frame cover **50** to the shell ejecting position of FIG. 7, and is thereupon returned to the firing position of FIG. 4, the plunger assembly of FIG. 13 will cause the cross slide camming member to snap into the position shown in FIG. 1 and FIG. 8, when the frame cover **50** has been restored to the position that its cutout **118** becomes re-aligned with the frame cutout **125**. It will be observed with reference to FIG. 8, that in this centered position of the cross slide cover **110**, the lower cam portion **108** of the cross slide camming member has entered the frame slot **125**, to about half the depth thereof, whereby the frame cover **50** is again locked in position to the frame barrel **2**, to prevent longitudinal displacement with respect thereto. It will further be noted with reference to FIG. 8 that in this locked position of the frame cover on the barrel, the upstanding lug **116** on the cross slide cover is again positioned in the path of the hammer portion **77**, thus to prevent actuation of the firing mechanism.

Referring more particularly to FIGS. 1, 2, 4, 14 and 23, the conduit **150** to be cut, is positioned in the hook-like retainer arm **3** of the tool frame, and against a pair of arcuate bushings **151, 152**, these bushings being secured to the rear of the retainer arm by means of a pair of bolts **153, 154**, which extend through the rear of the retainer arm and thread into the bushings. As shown in FIG. 2, these bushings are spaced apart slightly in excess of the width of the cutter blade **15** and the retainer arm or work support **3** of the frame is centrally slotted as at **155**, FIGS. 2 and 23, for passage of the cutter blade in severing the conduit to the position illustrated in FIG. 6. This slot **155** terminates at the rear end of the retainer arm **3** in a vertical bore **156** from which the chips resulting from the severing of the conduit may be dumped by inverting the tool.

As above stated, there is resiliently mounted on the frame cover **50** at the muzzle end thereof, a clamping assembly **57**, which includes a metal clamping member **157** of substantially U-shaped configuration viewed in end elevation, FIG. 12, and which spans the frame cover **50** and is formed at its opposite ends with turned down or depending arms **158, 159**. These arms have the configuration, viewed in side elevation, best shown in FIG. 4, and are provided with arcuately curved lower front edges, as at **160**, adapted to engage the surface of the conduit **150** and thereby force the same against the bushings **151, 152**. The clamping member **157** is loosely secured to the frame cover **50** by means of a guard screw **161** which passes through an oversize central aperture of the clamping member, and is threaded into the frame **50**. Adjacent the guard screw the clamping element is provided with a struck-up, apertured portion, as at **162**, in which is mounted a resilient cushioning element **163** of rubber or equivalent, which rests on the top of the frame cover **50**, and thus resiliently supports the clamping member **157** in spaced relation to the frame cover **50**. As the frame cover is moved to the firing position of FIG. 4, the arcuate edges **160** of the clamping element arms **158, 159**, engage the conduit **150** and force the same gainst the bushings **151, 152**, and in so doing rotate the clamping element **157** clockwise about the axis of support provided by the guard screw **161**, whereby the cushioning element **163** is flattened somewhat from the position of FIG. 4 to that of FIG. 6, thus resiliently clamping the conduit **150** in position in the manner shown in FIG. 6.

To further assist in the supporting and clamping of the conduit, there is mounted at the base of the frame arm **3**, an arcuately surfaced segment member **164**, held in position by a bolt **165** threading into the base of the frame arm **3**, this segment being centrally slotted as at **166**, FIG. 2, to provide passage of the cutter blade past the same. The arcuate face **167** of this segment supports the under side of the conduit in the manner best illustrated in FIG. 4. After the conduit is severed by the cutter blade in the manner illustrated in FIG. 6, retraction of the frame cover **50** of course, retracts the clamping element **157** along with it, thus to permit of inserting a new conduit section in the frame arm **3** to be cut.

Referring more particularly to FIG. 2, it is seen that the bushings **151, 152**, are of symmetrical configuration, thereby providing cutting edges on both sides of each as at **168, 169**, whereby these bushings may be inverted or reversed in position, thus to utilize the cutting edges on both sides of each. Bushings of differing arcuate curvature are provided for conduits of radically differing diameters to be cut, although it is to be noted in this connection that the arcuate contour of the bushings need only roughly approximate that of the conduit to be cut due to the clamping action of the clamping element **157** and the supporting action of the segment **164**.

Referring to FIGS. 1 and 4, it will be observed that when the cover **50** is advanced to the firing position, the forward end of the cover covers the open **C** of the hook-like retainer arm **3**, so that the cover is thus in this closure position whenever the conduit is to be severed. As thus closed the cover insures that the conduit cannot be half-in and half-out of the die bushings **151, 152**, when the tool is fired. The frame cover **50** as thus closed automatically and safely covers the region into which the shear cutout conduit chips are thrown, and permits them to be dumped out when the cover is open. The operator is thus shielded against flying chips of metal.

Extensive experimental tests have shown that the thickness and profile of the cutter blade **15** have considerable effect on the cutting action, as regards severing of the conduit without denting. Referring to FIG. 15, these tests have established that for the cutting of steel conduit, the point of the blade should be of substantially V shape and should have an included angle **176** of substantially 60°. The thickness of the blade may vary with the character of the work support. Assuming a work support **151, 152** of the type shown in FIG. 4, the blade thickness for effective cutting without distortion may vary from about .05" to about .25", an optimum thickness being .07" to .08". Thicker blades are more durable but require greater driving force. They also have a tendency to distort tubular work, due to the radial outward flow of the tubular stock adjacent the point of entry of the blade. However, by providing a full 360° exterior work support, the blade thickness may be increased up to at least as much as 1", an appropriate driving force being provided. Referring to FIG. 15, the point of the blade may have a rake angle of 30° both above and below the median line, but preferably has a rake angle of about 30° above the median line and about 32° below the median line, as shown, for holding the blade down as it passes through the conduit. Referring particularly to FIGS. 3, 4 and 6, it will be seen that the lower blade guideway **17** is backed by the solid metal of the frame, while the upper edge of guideway **16** is defined by the filler strip or insert member **38** held in place by cross-pins. The flatter angle of the upper part of the blade point precludes any tendency of the blade to climb and distort the filler **38** or shear the fastening pins should the blade point impact the cylindrical surface of the workpiece above center. Our investigations have shown that blades having an included angle of up to 90° can be satisfactorily employed for the severing of steel conduit, and such blades having the 90° included profile angle have been shown to be most sturdy. However, for the severing of conduit made of materials like copper or brass, which have a galling or binding action on the blade, a blade having a double concave configuration such as that shown in FIG. 16 is most satisfactory to assure dent-free severing of the conduit. The cutting blade is preferably made of a chisel steel, such for example, as a relatively high carbon, low alloy steel containing, for example, about: 0.55% carbon, 1% manganese, 2.3% silicon, 0.5% molybdenum, 0.25% vanadium, balance iron except for the usual impurities, such as phosphorus and sulfur, within commercial tolerances.

The action of the cutter blade in severing the conduit is illustrated in FIGS. 27–29, inc. When the cutter blade first penetrates the cylindrical conduit, the line of contact is a short chord, so that a substantial part of the penetrating force is applied in a radially inward direction. The conduit is sheared at the two edges of the cutter, and the chips **170, 171** thus produced are pushed inwardly, as shown in FIG. 27. As the cutter point approaches the center of the conduit, the line of contact shifts from a chord to a radius, and the force becomes tangential. Thereafter, an increasing component of the force is outward, instead of inward. Accordingly, as the point of the cutter passes the center, chips **170*a***, **171*a*** begin to form on the outside of the conduit. When the cutter point reaches the back of the conduit the force is applied outwardly and the chips **172**, **172*a*** which form at this point may be continuous with the chips **170*a***, **171*a***. In the meantime, the interior chips **170, 171**, have been severed from the conduit, usually being caught com-

pressed and distorted between the shear blade and the interior face of the conduit, and finally expelled lengthwise of the conduit in two parts.

To insure that the work is cut completely through, it is necessary to impart to the piston and blade assembly an excess of say 25% of the energy actually required to sever the work or to perform other operations heretofore outlined, and, to stop the movement of the piston and tool assembly after its work is completed, a buffer is associated with this assembly. In a preferred form of the invention, this buffer comprises two elements, the first being a stack of radially elastically deformable members and the second a "ring spring" type of assembly comprising one or more members which are radially elastically deformed and under excessive stress undergo a plastic deformation. Such excessive stress may be applied when the tool is inadvertently fired without a workpiece in place. Under these conditions the buffer assembly must absorb the entire kinetic energy of the piston and blade assembly, there being no other resistance to the forward movement of this assembly. The construction of the tool may be such that plastic deformation of the ring spring disables the tool, in a manner to be described, both indicating that the tool has been fired without a workpiece in place and necessitating replacement of the plastically deformable ring. As particularly shown in FIGS. 17 and 18, the elastically deformable shock absorbing component is identified generally by numeral **179** and the elastically and plastically deformable member by numeral **180**. The function of the elastically deformable shock absorbing component **179** is to absorb the excess kinetic energy of the piston, over and above that required to sever the conduit when the tool is fired and the piston impelled thereafter against the impact surface **24** of the frame. The function of the plastically deformable member **180** is to absorb the excess kinetic energy of the piston on firing, which is not taken up in severing the conduit, and in elastic deformation of the shock absorbing member **179**, such as occurs, for example, if the tool is inadvertently fired with no conduit in the retainer arm.

In order for the elastically deformable shock absorbing component **179** satisfactorily to perform its function above stated, it must be designed to meet two rigid requirements. First, the compression modulus of elasticity of this member must be such as to decelerate the piston without exceeding the tensile strength of the blade. In this connection it will be observed that upon impact of the piston against the frame impact face **24**, tending abruptly to stop the piston, the inertia of the blade places the same under tension so that if the piston is stopped too abruptly, the cutter blade will fail in tension. Therefore the shock absorbing component **179** must have a modulus of elasticity which is sufficiently low as to decelerate the piston at a rate sufficiently low that the tensile strength of the cutter blade is not exceeded. The second requirement which the shock absorbing component **179** must meet is that it must be capable of supporting a compression load equal to the tensile strength of the blade. This is explainable as follows: As the front face of the piston impacts the frame impact face **24**, the shock absorbing component becomes analogous to a compression spring, the rear end of which is connected to, and compressed by, the piston cap **19** threaded onto the terminus of the blade shank **18**. The momentum of the blade is thus resisted by the force exerted by the spring as it is compressed. If this spring has too high a compression modulus, the blade will fail in tension. Metal springs, even in coiled forms of low modulus, have nevertheless too high a compression modulus, and, being made of metal, a shock wave is built up that outraces the load velocity and "sets" the spring. On the other hand, solid plastics have too high a compression modulus, and, in addition, cannot withstand the compressive forces which their high modulus quickly produces. For example, leather approximates a satisfactory modulus, but fails in compression loading during repeated cycles, because its outer tough fibers break loose from their supporting matrix. Rubber and rubber-like material, including the synthetic rubbers such as neoprene, display a compression modulus somewhat under that of leather, so that considerably more stroke is required to store the same energy. While rubber and equivalent materials can withstand heavy loading with elastic recovery, they require support within a container both to raise their natural modulus and to prevent shredding failure under load. As thus compressed in a container, for example, in a steel sleeve, rubber behaves like an incompressible fluid, exerting tremendous hydraulic pressure on the surrounding container. The strength of the retainer thus required cannot be provided in a tool of reasonable size.

In accordance with one aspect of the present invention, this problem is successfully solved in a compact structure by making the elastically deformable component **179** of a laminated construction and consisting of a series of axially aligned metal rings **181**, such as steel shims, which are interleaved with other rings **182** formed of woven fabric, preferably woven nylon fibers, which are impregnated with an elastic polymer, preferably neoprene. This laminated arrangement is assembled, in axial alignment as shown, on a steel assembly tube **18***b* between an impact plate **184** mounted on the forward end of the assembly tube and an annular spacer member **185** assembled on the rear end of the assembly tube. To facilitate this assembly, the assembly tube is formed with a flanged terminus **186** at its rear or left end in the drawing and the spacer member **185** is formed with a conforming axial counterbore, which seats against this shoulder. The assembly tube at its opposite end is crimped up against the impact plate **184** as at **187**, thus to lock the entire assembly together.

In this assembly, in the elastic polymer-impregnated fabric rings **182**, such as the neoprene impregnated woven nylon fibers, the fibers act as stay bolts to hold the elastic polymer or neoprene from expanding, and thus absorb the lateral strain on these rings resulting from impact of the piston against the frame impact face **24**. Neoprene has been found to be a convenient elastic binder for nylon fibers, and thus facilitates the establishment of a synthetic modulus of elasticity which neither the nylon alone nor the neoprene alone can possess. The surface of the steel shims separating the layers of impregnated fabric are preferably roughened, as by sand-blasting. These shims frictionally support the fabric layers, giving added strength and retarding radial expansion; their friction against the fabric also dissipates a substantial amount of energy. When, as illustrated, the plastically deformable member **180** is used in conjunction with the shock absorbing component **179**, the latter is of such length and construction as to sustain without plastic flow a compression substantially equal to that which will initiate elastic deformation of the member **180**.

Referring to FIG. 18*a*, by appropriately dimensioning the elastic polymer impregnated fabric rings **182** in relation to the metal rings **181**, the modulus of elasticity **188** of the elastically deformable component **179** may be sloped as desired within limits, thus to adjust the deceleration of the piston in accordance with the requirements above stated.

Because of the requirement that the piston weight be minimized, the amount of elastic shock absorption that can be built into the shock absorbing component **179**, is limited, and the excess must be taken up by the plastically deformable member **180**, both as regards excess kinetic energy resulting from the conduit severing operation, and more particularly as regards the excess kinetic energy resulting from inadvertent firing of the tool with no conduit mounted in the retaining arm. This latter is strictly a protective feature to prevent injury to the cutting blade, piston and the tool itself resulting from such inadvertent firing. To this end the plastically deformable member

180 comprises a ring made of a malleable metal like aluminum or an aluminum alloy of such dimensions that it will fail in compression before the other tool components will fail in tension. That is to say, the compression strength of the plastically deformable member **180** must be substantially less than the tensile strength of the tool frame, cutting element and piston. It will be noted in this connection that when the piston impacts the frame impact face **24**, the tubular portion of the frame is placed under tension. Likewise, as above explained, the cutting element is placed under tension due to its inertia. As shown in FIG. 17, the plastically deformable member **180** of malleable metal is of trapezoid configuration, as viewed in axial section, and is mounted between the spacer member **185** and the piston cap **19**, both of which are made of a metal having a high elastic limit, such as steel. The abutting surfaces **190**, **191**, between the plastically deformable member **180** and the adjacent steel spacer and piston cap members **185**, **19**, are preferably sloped in accordance with the minimum slope or friction angle of the contiguous metals, i.e., aluminum vs. steel in the preferred modification as above mentioned, thus to enhance the energy absorption by the plastically deformable member **180** as the latter is plastically deformed, and squeezed from the full line sectional area **180***b* to that of the dotted line **180***a*.

Thus the camming angles of the sloped surfaces **190**, **191**, approximate the friction angles between the contacting metal surfaces, so that the yield strength of the plastically deformable member **180**, is mechanically increased by the friction. The plastically deformable member **180** shown, approximates a rectangular stress-strain diagram for maximum efficiency of energy dissipation as a function of piston stroke. The maximum force developed thereon accordingly never exceeds a value exceeding the tensile strength of the cutter blade and shank.

Referring again to FIG. 18*a*, the plastic deformation of the member **180** may be designed to occur at any given load level such as **192**. As a result, therefore, of the composite assembly comprising the elastically deformable shock absorbing component **179** and the plastically deformable energy absorption member **180**, the composite load compression graph thereof will be approximately as indicated at **188**, **192** of FIG. 18*a*. That is to say, as the piston impacts the frame shoulder, the impact of the piston against the shoulder will at first be gradually absorbed by elastic deformation of the shock absorbing member **179** (and, of course, any elastic deformation of the member **180** as does occur), along the line **188** of FIG. 18*a*, until a load corresponding to the level **192** is reached at which the elastic limit of member **180** will be exceeded, whereupon the additional load will be assumed by plastic deformation of the plastically deformable member **180** which holds the load substantially constant thereafter at the level **192** as shown in FIG. 18*a*.

It should be noted that in the ordinary usage of the tool the plastically deformable member **180** is not deformed beyond its elastic limit and that it is only in the event that the tool is operated without a workpiece in place that the stress applied to this ring is sufficient to plastically and permanently deform it. Under some conditions, it is desirable that such permanent deformation of the plastically deformable member **180** be indicated and disable the tool until such is replaced. This can be accomplished by providing that permanent deformation of the plastically deformable member **180** increases its diameter beyond the bore diameter of the barrel sleeve **5** in the manner illustrated in FIG. 18*b*. In this condition, when an attempt is made to retract the piston to firing position, the margin of plastically deformable member **180** engages the end **5***a* of the barrel sleeve **5**, preventing complete retraction of the piston.

While the buffer above described comprises both an elastically deformable component **179** and a plastically deformable member **180**, where space requirements permit, it is possible to so extend and enlarge the elastically deformable member **179**, as to provide the energy absorption capacity needed for firing in the absence of a workpiece without the use of the plastically deformable member **180**. Either arrangement is adapted to use in a stud driving tool, as distinguished from a cutting or swaging tool, the former as illustrated in FIG. 51, in which the tool shank **14***a* terminates in an enlarged end **146**, recessed and threaded to receive the threaded shank of a stud **14***c*, which is designed to be fired into a difficultly penetrable material, such as aged concrete or steel. When such a tool is fired in the absence of work which will stop the stud after the desired penetration, the stud, instead of being projected into space, is retained by its threaded connection to shank **14***a*, the kinetic energy of stud, tool and piston being all absorbed in the buffer device **179***a*.

Reverting to FIGS. 17 and 18, while the elastically deformable component **179** is a buffer and preferably comprises layers of impregnated fabric alternating with metal shims, under some conditions it is posisble to omit the shims and place successive layers of impregnated fabric in face-to-face relation. It is essential, however, that the buffer comprise a plurality of rings or disks of fibrous material held in an elastic impregnating medium, such that the transversely disposed elastic fibers and the elastic impregnant interact to oppose radial deformation while enabling the required longitudinal deformation.

Reverting to FIG. 17, the piston impact plate **184** is likewise preferably made of a malleable metal like aluminum or an aluminum alloy, having a compresison strength substantially below that of the metal of the frame **1**, which latter is made of steel. The purpose of this is to assure that the impact plate will fail through compression before the steel frame is broken under tension, this being an additional safety precaution in the piston construction. Moreover, the stress incident to stopping the piston assembly, either in normal usage or in firing without a workpiece, is received by the main frame barrel **2**, and not by the work support **3**, thus avoiding any bending stress in the curving connecting shank **3***a*.

Reverting to FIGS. 1 and 4, the tool is provided with a handle **200** of wood, hard rubber or equivalent, which is assembled on the under side of the tubular frame section **2**, by means of bolts, as at **201**, **202**, threaded into the frame.

In assembling the tool from its components, the piston and cutter assembly **14**, **15** are first inserted in the frame barrel **2**, with the upper and lower edges of the cutter blade aligned with the grooves **16**, **17**, in which the blade slides. The sleeve barrel **5** is thereupon inserted against the shoulder **4**. Since the bore of the sleeve barrel **5** is less than that of the width of the cutter blade **15**, it is apparent that the piston and cutter assembly **14**, **15** must first be inserted, for this reason. The barrel plug **6** is then inserted in the breech end of the frame and the cartridge chamber plug **7** inserted in the aligned holes **8**, **9**, and rotated until the pin **12** of the barrel plug seats in the notch of the chamber plug. As thus positioned, the slot **70***b*, FIGS. 4 and 23, cut in the upper face of the chamber plug **7**, is positioned to seat the ejector end **72** of the cartridge ejector **66**.

The enlarged head of the barrel plug **6** assures that the proper end will be inserted in the frame barrel **2**. The chamber plug cannot be inserted until the barrel plug has been rotatively positioned with its bore **8**, in alignment with the frame bore **9**. The chamber plug cannot be incorrectly inserted by reason of its enlarged head **10** which can seat properly in the barrel plug counterbore **11** only when the plug is inserted as shown in FIG. 4.

With the aforesaid components thus assembled as shown in FIG. 4, the cover **50** may then be slid into position on the frame, to effect which the piston return bolt **63** must first be removed. As the cover is advanced to the firing position shown in FIG. 4 the frame cover pin **61**

engages the shoulder **60** of the insert member **38** thus to limit the forward displacement of the cover. Also the cross slide **56** will snap into place in the cover cutout **118**, FIG. 24, due to the centering action of the resiliently mounted plungers **130, 131**, FIG. 13. The piston return bolt **63** is thereupon inserted and threaded into the cover **50**. The tool is now ready for operation.

The method of operation is as follows: In loading the tool, the firing unit **55'** is grasped with one hand and one of the fingers thereof used to shift the cross slide protective device **56** to the release position. The firing unit **55'** and cover can then be drawn back to the cartridge ejecting position, thus exposing the open **C** at the front of the tool frame into which a section of conduit may be placed against the bushings **151, 152** and the member **164**. Also exposed in this position is the aperture **70** in the cross slide cover, into which a blank cartridge **22** is dropped into the cartridge chamber bore **21**. The bolt is then pushed forward, and, in one motion, completely encases the conduit and cartridge, the conduit being resiliently gripped by the clamping device **57**. The cross slide protective device **56** is then shifted to the firing position, locking the cover to the frame, whereupon the trigger **87** may be pulled to fire. Thereafter the cross slide protective device **56** is shifted to the release position, whereupon the cover again be withdrawn to the cartridge ejecting position by grasping the breech bolt, the spent shell thus being ejected through the cross slide cover aperture or opening **70**. The severed pieces of conduit can now be removed from the now open **C** of the frame retainer arm. The tool is then inverted whereupon the sheared conduit chips fall out of the tool. An absolute minimum of manual motion is thus entailed from start to finish.

A feature of the tool resides, as above noted, in the chambering of the cartridge at right angles to the motion of the piston as illustrated in FIG. 4. There are a number of advantages in this feature. Since captive piston tools of the type shown, generally have a barrel bore diameter considerably in excess of the cartridge diameter, the right angled chambering of the cartridge chamber facilitates the loading of the large diameter piston ahead of the relatively small shell, without necessity for providing a safe, foolproof joint at the front end of the tool for muzzle loading of the piston, such as would otherwise be necessary if the cartridge chamber were axially aligned with the piston at the breech end of the tool. Moreover, since the barrel bore is considerably larger than that of the shell, the total force of the piston in the barrel plug is many times that of a conventional firearm. The cylindrical cartridge chamber member, inserted at right angles to the piston axis, through the frame and barrel plug apertures, provides a massive locking pin which secures and resists this high total explosive force occurring in the barrel bore. Again a tool of the type shown, employing a captive piston which is not ejected from the tool, tends to accumulate more powder residue than occurs in a conventional firearm. The right angle cartridge chamber assembly provides a means of instantaneous takedown or disassembly in the manner above described, so that all surfaces of the piston chamber and barrel bore can easily be cleaned with a brush. Also the right angled cartridge chamber assembly provides a tool of minimum length. A much greater length of tool would be required in a construction wherein the cartridge chamber is axially aligned with the barrel of the piston. A further advantage of this construction is that a cartridge chamber plug for handling cartridges of a given caliber, can easily be replaced by other cartridge chamber plugs of similar construction adapted for the insertion of cartridges of larger caliber, by simply making the cartridge bore of the requisite diameter and offsetting the same from the centerline whereby any caliber rim fire cartridge can be employed without necessity for relocating the firing pin. Since the barrel plug and cartridge chamber plug assembly provide, upon removal, the only entry through which the piston and cutter assembly can be inserted, this construction eliminates the necessity for safety interlocks that would otherwise be required, if the piston and cutter assembly were side or front loaded into the tool frame.

Referring to FIG. 4, mention was made above of the fact that the terminal portion **20** of the steel piston cap **19** is of considerably reduced diameter as compared to the bore of the sleeve barrel **5** and the piston **14**, and that this reduced diameter terminus of the piston cap fits into a corresponding bore **20*a***, in the forward end of the barrel plug **6** through which the explosion chamber **21** has access to the bore **20*a*** through the apertures **23*a*, 23** in the cartridge chamber and barrel plug, respectively. The significance of this is that experimental tests have shown that with a barrel of relatively large bore, such as that of the barrel **5**, the initial expansion volume for the burning powder from the cartridge **22** is provided at so great a rate, as the piston moves forward, that combustion of the powder is irregular. Powder of sufficiently fine granulation to be "quick enough" for a barrel of the relatively large bore of the barrel **5**, is not commercially available, and would be dangerous to handle industrially even if it were. The smaller diameter protuberance **20** extending from the piston cap **19** into the barrel plug bore **20*a***, provides a smaller bore diameter during the period of powder burning as the piston initially moves forward, and a larger diameter bore during powder gas expansion, the latter as the piston cap protuberance moves out of the barrel plug cavity to permit of an expansion of the gases into the larger bore of the barrel **5**. It will further be noted in this regard, that this protuberance **20** on the piston cap is nevertheless of considerably larger bore than the diameter of the shell **22** itself, and thus provides an initially exposed effective piston area large enough to apply tremendous acceleration to the piston by the powder up to the time it is completely burned, but at the same time, does not permit the powder to "snuff out" by the pressure drop that might otherwise occur if the explosion chamber bore **21** had access directly to the large bore of the barrel sleeve **5**. With the arrangement shown, it is not until the powder is completely burned that the large bore of the barrel sleeve **5** is uncovered, so that the gas, expanding, can act on the larger piston area during the remainder of travel. A large diameter piston has the distinct advantage in providing maximum expansion volume for powder gas in a tool of minimum length, such as that shown. A tool of the relative dimensions shown having a bore of about 1" for the barrel sleeve **5** and an effective length of the frame barrel of about 1⅝" provides an explosion chamber which would be equivalent to a barrel of about 22" in length, provided the piston were of the same caliber as the shell.

Referring to FIGS. 2, 4–11, inc., the frame slot **37** in which the piston return bolt **63** is displaceable, also provides, as above noted, a gas escape passage communicating at one end with the bore of barrel sleeve **5** and at its opposite end with the frame outlet aperture or passage **25**. This passage, as shown by the lines of arrows in FIGS. 2, 6, 7 and 9, leads the gases above and beyond the piston and deposits them against the workpiece clamped in the frame **C** arm, as soon as the piston has passed out of the barrel sleeve **5**. In this passage the gases expand so as to minimize the blast effect, and by directing them against the workpiece, which is covered by the frame cover **50** during firing, protects the operator against them. By providing for escape of the gases in this way they have a "swept" or "aspirating" effect on the barrel residue. This is in contrast to expedients heretofore employed in certain captive piston type tools wherein no gas outlet passage is provided and in which the gases are caused to expand and cool in the barrel, with the result that such tools must be frequently cleaned.

Referring now to FIGS. 30–32, inc., there is shown a modification of the tool construction above described

for varying the explosion force on the piston 14 from a blank cartridge 22 of standard charge. In this embodiment the sidewall of the cartridge chamber plug 210 is drilled through and counterbored opposite the outlet passage to slidably receive respectively the tip 211 and flanged head 211*a* of a screw 212 threaded through the barrel plug 213 and provided at its outer terminus with an indexing head 214. The barrel plug is also counterbored, as at 215, for slidable reception of the flanged head 211*a*. Retraction of flanged head 211*a* in counterbore 215 adds to the chamber volume any desired fraction of the volume of said counterbore; thus, enabling a control of the burning characteristics of the powder and the maximum pressure developed thereby throughout a range determined by the volume of counterbore 215. In this way the force impelling the piston from a blank cartridge of standard charge may be adjustably preset in accordance with the work force required of the tool mounted on the piston. As shown in FIG. 31, the knob 214 is indexed, as at 216, in proportion to the variation in explosive force resulting from any given adjustment. Also referring to FIGS. 30 and 32, the barrel plug has resiliently mounted therein a positioning detent 217 adapted to engage peripherally spaced notches 218 of the knob for presetting the knob in accordance with desired setting.

Reference will now be had to the bar stock cutting modification of the invention shown in FIGS. 33 and 34, wherein like elements are similarly designated as in FIGS. 1–23, inc. In this modification the bar stock 230 to be cut, is assembled in the retainer arm or work support 3 of the tool frame 1, against the arcuate or V-shaped front face 221 of a bushing 222 secured to the frame retainer arm 3 by means of a bolt 223, extending through a bore of the retainer arm and threading into the bushing as shown in FIG. 34. Secured to the frame cover 50 by means of a screw 224 is a substantially U-shaped clamping member 225 which transversely spans the cover 50 and has arms 226, 227 extending downwardly on opposite sides of the cover, these arms being provided with arcuate faces as at 228, which engage the front surface of the bar stock 220, with the cover 50 in the firing position of FIG. 33, thus to clamp the stock in position.

A cutter blade 229 for severing the bar stock, is mounted in advance of the piston 14, and is slidable in guides 230, 231. The cutter blade terminates at its rear end in a shank 232 which extends through the central assembly tube of the piston, and is secured thereto by means of the piston cap 19 in the manner above described with reference to the piston and cutter assembly of the previous embodiment. The muzzle end of the frame section 2 is vertically slotted as at 233 for passage of the cutter blade therethrough to the bar cutting position. FIG. 33 shows this tool modification with the piston and cutter blade in the firing position, while FIG. 34 shows the piston and blade advanced to the cutting position to sever the bar stock 220 in the manner illustrated.

The cutter blade 229 is preferably provided with a semicircular cutting edge 229*a* conforming to the diameter of the stock 220 to be severed, since this has been found to minimize the powder charge required for cutting and deformation of the stock. These same advantages result to a lesser extent if the arcuate contour of the cutting edge approximates in lesser degree the contour of the stock.

FIG. 35 shows a modified arrangement for clamping the bar stock 220 against the arcuate face of the bushing 222. This clamping mechanism comprises a relatively long lever arm 234 which, in the clamping position, extends along and rests against the under side of the tool handle 200 in the manner illustrated. This lever arm fulcrums about the point 235 of the frame retainer arm 3, against which point bears an adjusting screw 236 tapped through the terminus 237 of the lever arm 234 as shown. A link member 238 is pivotally connected at one end to the lever arm 234, as at 239, and at its opposite end, as at 240, to a clamping arm 241 which is pivotally mounted on the frame by means of a bolt 242, about which this clamping arm fulcrums.

To manipulate, the lever arm 234 is grasped and rotated counter-clockwise about the fulcrum point 235. This forces the link 238 to be displaced downwardly and to the right, thus rotating the clamping arm counter-clockwise about its fulcrum point 242 to its unclamped position. A section of bar stock 220 is thereupon inserted against the bushing 222 and the lever arm 234 manipulated in the opposite direction from that first described, i.e., it is now rotated clockwise about the fulcrum point 235. This reverses the direction of movement of the link 238, forcing it upward and to the left, whereby the clamping arm 241 is rotated clockwise about its fulcrum point 242 to clamp the bar stock 220 against the bushing 222. In the clamping position shown in the drawing the pivot point 239 of the link 238 is just above the dead center line established between the fulcrum point 235 of the screw 236 and the pivot point 240 of the link 238, thus providing a locking position. By adjusting the screw 236 in and out, the clamping assembly may be adjusted for clamping of bar stock of different diameters.

In the modification of the invention shown in FIG. 36 adapted for riveting, the tool frame 1 terminates flush with the muzzle end of the tubular frame section 2, as at 250, the C-shaped retainer arm of the previously described modifications being omitted. The rivet header or plunger 251 has integral with the rear end thereof a shank 252, which extends through the central assembly tube of the piston 14, and is secured thereto by means of the terminal piston cap 19 in the manner above described with reference to previous modifications. The muzzle end of the frame 1 has an outlet aperture 253 of a bore somewhat in excess of the diameter of the plunger 251, so that the plunger may pass freely therethrough together with the explosion gases. The outlet terminus of passage 253 is arcuately contoured over a sector 254, in conformity with the concave arcuate contour 255 of the plunger face, thus to impart a hemispherical contour to the swaged rivet head. The arcuate sector 254 terminates in a cylindrical bore 256 in which is assembled a thin-metal, centering disk 257 of cup-like configuration as shown. The barrel plug 6 inserted in the breech end of the frame 1, has mounted thereon, in this modification, a grip or handle 258, secured to the barrel plug by means of a threaded bolt 259, for purposes of applying pressure on the tool against the workpieces to be riveted together such, for example, as the angle member 260 and the channel member 261.

These angle and channel members are provided with holes as at 262, 263, for reception of a rivet 264, held in position during the riveting operation by means of a bucker 265, manipulated by a second workman. In the action position the first workman who actuates the tool, presses the same by means of the handle 258, firmly against the assembled workpieces 260, 261 in the relative positions illustrated in the drawing and thereupon actuates the trigger to impel the plunger 251 against the inner end 266 of the rivet, as a result of which this end is swaged to the hemispherical configuration shown at 267 of FIG. 37, thus to rivet the two workpieces 260, 261 together.

FIG. 38 shows a further modification for the application of so-called "Cherry" riveting. In this modification the plunger 270 assembled to the piston 14 in the manner aforesaid, is provided with a flat faced terminus 271. As in the previous modification the tool frame 1 terminates flush with the muzzle end of the tubular frame section 2, and the muzzle end of this frame section is drilled as at 273 with sufficient bore to permit passage of the plunger 270 therethrough. The work pieces 274, 275 to be joined by means of a Cherry rivet are apertured, as at 276, for reception of a rivet 277 of this type, which is inserted as shown with its hemispherical head 278 engaging a correspondingly contoured terminus 279 of the frame muzzle.

The usual steel pin 280 is placed in the counterbore of the Cherry rivet aperture, and, upon firing is impacted by plunger 271, driving the pin home into the rivet and thereby enlarging the end of the rivet shank to secure workpieces 274 and 275 together, as shown in FIG. 38*a*.

Referring now to FIGS. 39 and 40, the modification of the invention shown for staking a threaded terminus on the end of a section of electrical conduit, or for joining two such conduit sections together by means of a coupling sleeve, comprises a pronged staking blade 290, assembled to the piston 14 in the manner above described, this blade being slidably displaceable along grooves 291, 292 of the tubular frame section 2. The muzzle end of this frame section is vertically slotted, as at 293, for passage of the staking blade therethrough to the staking position. Mounted in the retainer arm 3 of the frame, is a pronged bushing 294, of configuration corresponding to the staking blade 290. This bushing is secured to the frame by means of a threaded bolt 295, extending through a bore of the frame and threaded into the bushing as shown in FIG. 39. The workpieces to be joined, such as one end of an electrical conduit 296 and a slotted and threaded terminus therefor 297, are assembled against the bushing 294, in the manner illustrated in FIG. 39, and are held in place by means of a substantially U-shaped clamping member 298, which spans the frame cover 50 and is resiliently mounted thereon by means of an interposed rubber pad 299, the assembly being secured by a threaded bolt 300 threading into the frame cover. The clamping member has a pair of depending arms as at 301, which engage the front face of the workpiece assembly 296, 297, with the frame cover 50 advanced to the action or firing position as shown.

When the tool is fired, the staking blade 290 is impelled against the conduit 296 and within the slots 302, 303 of the threaded terminus 297, thereby to partially shear and upset the conduit metal in the manner illustrated at 304, 305 in transverse section in FIG. 40, thus to secure the threaded terminus 297 in locking engagement with the conduit 296.

Referring to FIGS. 43 and 44, there may be interposed between the end of the conduit 296 and the threaded terminus 297 a rubber gasket 306 or the like. And for so shearing and upsetting the metal of the conduit as to force the end of the conduit snugly against the threaded terminus 297, and thus compress the gasket 306, the prongs of the staking blade 290 and of the cooperating bushing 294 may be set at an angle as illustrated at 307, 308 of FIG. 43, thus to shear and displace the conduit metal in the manner illustrated at 309.

Referring to FIG. 45, for uniting two conduit sections 310, 311 by means of an interposed coupling sleeve 312, having formed therein pairs of oppositely disposed slots as at 313, 314, one conduit section 310 is sleeved into the coupling member and the assembly mounted in the tool retainer arm 3 in the manner illustrated in FIG. 39. The tool is then fired, thus to stake the conduit to the coupling as shown at 315, thus to lock the coupling section 312 and the conduit terminus 310. Thereupon this same operation is repeated with the conduit terminus 311 assembled in the opposite end of the coupling member 312 against the bushing 294 of the retainer arm 3, and the tool again fired, to stake these two components together as at 316.

Referring to the hole punching modification of the invention shown in FIGS. 46 and 47, an annular shearing die 320 is mounted in a bore 321 of the frame retainer arm or work support 3, this die being resiliently held in place by means of a detent 322 which engages a peripheral groove 323 in the exterior surface of the die, this detent being backed by a small compression spring 324, for resilient displacement whereby the die 320 may be snapped into place or removed. Mounted on the piston 14 in the manner above described is a plunger 325 of a diameter slightly less than that of the die aperture 326. The clearance between the punch and die is preferably somewhat greater than that commonly used in die sets operated by conventional means. The workpiece to be punched, such for example, as the angle iron 327, is mounted on a supporting screw 328 which threads through the base of the frame retainer arm 3 as shown, this screw being adjustable up and down by means of the handle 329 secured to the base of the screw. For holding the workpiece securely against the die 320 during the punching operation, there is pivotally mounted on the frame retainer arm 3, as at 330, a camming member 331 provided with a lever arm 332 for manipulation. When the tool is fired the plunger 325 advances from the firing position of FIG. 46 to the punching position of FIG. 47, thus to punch out a circular slug 333 from the workpiece which drops down into a cavity 334 formed in the retainer arm 3 behind the die aperture 326.

Reference will now be had to FIGS. 48–50, incl., showing a modification of the invention adapted for the swaging of an electrical terminal onto the end of electrical cable or for joining two cable ends together by means of an interposed sleeve. Assembled on the piston 14, as above described, is a swaging head or plunger 340, having a knobbed head 341. Mounted in the retainer arm 3, is a backing plate 342, secured in placed by means of a bolt 343 extending through a bore of the retainer arm 3 and threading into the backing plate. Assuming the tool is to be employed for swaging a terminus 344 onto the end of a cable section 345, the sleeve portion 346 of the terminal member is first assembled on the cable terminus 345, and the assembly then positioned against the backing plate 342 in the manner shown in FIG. 48, and held in place in the action or firing position, by a substantially U-shaped clamping member 347, which spans the frame cover 50 and is secured thereto by means of a screw 348, this clamping member having depending arms as at 349 adapted to engage the front face of the work piece assembly and hold it against the backing plate 342.

When the tool is fired the plunger 340 is advanced from the position of FIG. 48 to that of FIG. 49, whereby the knobbed head 341 of the plunger swages the sleeve portion of the terminal into snug engagement with the cable terminus 345 in the manner illustrated at 350, FIG. 49. For joining together two cable terminals 351, 352, FIG. 50, by means of an interposed sleeve member 353, the swaging operation above described is performed twice. That is to say, the sleeve 353 is first slipped onto the cable terminus 351 and the assembly mounted in the tool in the manner illustrated in FIG. 48 and the tool fired. The second cable terminus 352 is thereupon inserted in the opposite end of the sleeve 353 and the assembly thereupon again mounted in the retainer arm in the manner shown in FIG. 48 and the tool again fired. As a result of these two operations the sleeve 353 is swaged to the cable terminus 351 in the manner shown at 354 and to the cable terminus 352 in the manner shown at 355.

What is claimed is:

1. An explosively actuated tool comprising a frame including a barrel section having a breech end and a muzzle end, a piston slidable in said barrel section, closure means including a cartridge chamber at the breech end of said barrel section and having access thereto, piston retainer means integral with the muzzle end of said barrel section, an elongated rigid member attached at one of its ends to said piston to project therefrom towards said muzzle end of the barrel section, a work tool integral with the other end of said rigid member, and shock absorbing means mounted for movement on said rigid member between said piston and said work tool, said shock absorbing means comprising a stacked assembly of laminae of interlocked fibrous material impregnated with a resilient rubber-like polymer, whereby said shock absorbing means engages said piston retainer means at the end of a piston working stroke the stacked assembly of impregnated fibrous material will dissipate a large part of the shock of the stopping of said piston, and an abutment means

forward of said shock absorbing means for engagement with said retainer means.

2. An explosively actuated tool according to claim 1 wherein the elongated rigid member has disposed thereon a plastically deformable member disposed between said piston and said shock absorbing means.

3. An explosively actuated tool comprising, a frame including a barrel section having a breech end and a muzzle end, a piston displaceable therein, closure means including a cartridge chamber at the breech end of said barrel section and having access thereto, piston retainer means integral with the muzzle end of said barrel section, a work tool attachment element attached to said piston and projecting therefrom towards said muzzle end of the barrel section, a work tool carried by said attachment element, and shock absorbing means mounted for movement on said attachment element adapted to absorb energy resulting from impact of said shock absorbing means against said retainer means at the end of a working stroke of said piston, said shock absorbing means including an elastically deformable energy dissipating member comprising a stacked assembly of metal laminae interleaved with laminae of fabric woven material impregnated with a resilient rubber-like polymer.

4. An explosively actuated tool according to claim 3 wherein said work tool is a riveting tool.

5. An explosively actuated tool according to claim 3 wherein said work tool is a staking tool.

6. An explosively actuated tool comprising, a frame including a barrel section having a breech end and a muzzle end, a piston displaceable therein, closure means including a cartridge chamber at the breech end of said barrel section and having access thereto, piston retainer means integral with the muzzle end of said barrel section, a work tool attachment element attached to said piston and projecting therefrom towards said muzzle end of the barrel section, a work tool carried by said attachment element, and shock absorbing means mounted for movement on said attachment element and adapted to absorb energy resulting from impact of said shock absorbing means against said retainer means at the end of a working stroke of said piston, said shock absorber means comprising elastically deformable and plastically deformable shock absorbing members disposed seriatum in the direction of said impact, said elastically deformable member comprising a stacked assembly of metal laminae interleaved with laminae of fabric woven material impregnated with a resilient rubber-like polymer, and said plastically deformable member comprising a relatively thick section of a malleable metal plastically deformable upon the energy absorption capacity of said elastically deformable member having been substantially reached.

7. An explosively actuated tool comprising, a frame including a barrel section having a breech end and a muzzle end and terminating at the muzzle end in a hook-like arm section, a piston displaceable in said barrel section, breech closure means for said barrel section including a cartridge chamber having access to said barrel section and accessible from said breech end, and retainer means for said piston at the muzzle end of said barrel section, a cover displaceable along said frame between a retracted position and an advanced position thereof with respect to said frame, said cover when positioned at said retracted position exposing said cartridge chamber and when positioned at said advanced position covering said cartridge chamber and the open aperture of said hook-like arm, means on said cover for clamping a workpiece in said hook-like arm and cooperating means on said hook-like arm for clamping said workpiece in position with said cover disposed at said advanced position, and a work tool carried by said piston adapted to fabricate said work piece, and shock absorbing means mounted on said piston adapted to dissipate energy resulting from impact of said piston against said retainer means.

8. An explosively actuated tool comprising, a frame including a barrel section having a breech end and a muzzle end and terminating at the muzzle end in a hook-like arm section, a piston displaceable in said barrel section, breech closure means for said barrel section including a cartridge chamber having access to said barrel section and accessible from said breech end, and retainer means for said piston at the muzzle end of said barrel section, a cover displaceable along said frame between a retracted position and an advanced position thereof with respect to said frame, said cover when positioned at said retracted position exposing said cartridge chamber and when positioned at said advanced position covering said cartridge chamber and the open aperture of said hook-like arm, means on said cover for clamping a work piece in said hook-like arm and cooperating means on said hook-like arm for clamping said work piece in position with said cover disposed at said advanced position, and a work tool carried by said piston adapted to fabricate said work piece, and shock absorbing means mounted on said piston adapted to dissipate energy resulting from impact of said piston against said retainer means, said shock absorbing means comprising axially aligned elastically deformable and plastically deformable shock absorbing members, said plastically deformable shock absorbing member plastically deformable upon the energy absorption capacity of the elastically deformable shock absorbing member having been substantially reached.

9. An explosively actuated tool comprising, a frame having guide means for mounting a piston displaceable therealong, a piston assembly comprising a tool integral with said piston and mounted in said guide means, means at one end of said frame for impelling said piston assembly along said guide means and an impact member integral with the opposite end of said frame for stopping said piston assembly, and elastically deformable shock absorbing means mounted on said piston having a compression modulus such as to decelerate said piston assembly without exceeding the strength of said piston assembly, said means being of laminated construction and comprising axially aligned and interleaved metal rings and rings of fibrous material impregnated with a resilient rubber-like polymer, said means being capable of supporting a compression load substantially equal to the strength of said tool.

10. An explosively actuated tool comprising, a frame having guide means for mounting a piston displaceable therealong, a piston assembly comprising a tool integral with said piston and mounted in said guide means, means at one end of said frame for impelling said piston assembly along said guide means and an impact member integral with the opposite end of said frame for stopping said piston assembly, elastically deformable shock absorbing means mounted on said piston having a compression modulus such as to decelerate said piston assembly without exceeding the strength of said piston assembly and tool, said means being of laminated construction and comprising axially aligned and interleaved metal rings and rings of fibrous material impregnated with a resilient rubber-like polymer, said means being capable of supporting a compression load substantially equal to the strength of said tool, and a plastically deformable shock absorbing member mounted on said piston assembly in axial alignment with said shock absorbing means, said member comprising a relatively thick ring of material having a compression strength substantially below the strength of said frame and piston assembly and plastically deformable upon the energy absorption capacity of said elastically deformable member having been substantially reached.

11. An explosively actuated tool comprising a frame having guide means for mounting a piston displaceable therealong, a piston mounted in said guide means, means at one end of said frame for impelling said piston along said guide means, an impact member at the opposite end of said frame for arresting said piston, and shock ab-

sorbing and energy dissipating means on said piston comprising elastically deformable and plastically deformable members mounted in axial alignment, said elastically deformable member having a compression modulus such as to decelerate said piston without exceeding the tensile strength of said piston and tool and being of laminated construction consisting of axially aligned and interleaved steel rings and rings of woven nylon fabric impregnated with neoprene, and said plastically deformable member comprising a relatively thick ring of malleable metal having a compression strength substantially below the tensile strength of said frame and piston and plastically deformable upon the energy absorption capacity of said elastically deformable member having been substantially reached.

12. A tool adapted to sever tubular metal work without significant deformation of the work, said tool comprising, a work support, a frame having therein a gas receiving bore and a cutter guide, a cutter in said cutter guide, a piston slidable in said bore, a shank joining said cutter and said piston, piston retainer means integral with said frame for retaining the piston within said bore at the end of a working stroke, means for introducing into said bore a quantity of the product of the combustion of a solid fuel having an energy content in excess of the energy required to sever the work, said product of combustion to impel said piston in a working stroke, and shock absorbing means for dissipating such excess energy, said shock absorbing means mounted for movement on said shank and comprising a stacked assembly of fabric woven laminae impregnated with a resilient rubber-like polymer and means for thermally transmitting such excess energy to said frame.

13. A tool according to claim 12 wherein said means for thermally transmitting such excess energy to said frame comprises an abutment element mounted on said shank adapted to engage said frame near the end of a working stroke of said piston.

14. A tool adapted for severing bar stock, cables and the like, comprising: a barrel having a breech end and a muzzle end, a work support integrated to the muzzle end of said barrel, an apertured piston retaining abutment at the muzzle end of said barrel, means for introducing powder gas into the breech end of said barrel, a driven assembly in said barrel comprising, a piston having a cutting element projecting therefrom adapted to pass through the aperture of said abutment for severing a work piece mounted in said support, and shock absorbing buffer means mounted on said piston adapted to dissipate energy of impact of said driven assembly against said abutment and to arrest said driven assembly thereat, said shock absorbing buffer means comprising a stacked assembly of fabric woven laminae impregnated with a resilient rubber-like polymer.

15. A cutting tool according to claim 14, the cutting element of which has a cutting edge of concave arcuate cotour of a diameter at least equal to that of the work piece to be severed.

16. An explosively actuated tool comprising, a frame including a barrel section having a breech end and a muzzle end, a piston slidable in said barrel section, closure means including a cartridge chamber at the breech end of said barrel section and having access thereto, piston retainer means integral with the muzzle end of said barrel section, an elongated rigid member attached at one of its ends to said piston to project therefrom towards said muzzle end of the barrel section, a work tool integral with the other end of said rigid member, and shock absorbing means mounted for movement on said rigid member between said piston and said work tool, said shock absorbing means comprising a stacked assembly of laminae of interlocked fibrous material impregnated with a resilient rubber-like polymer, whereby said shock absorbing means engages said piston retainer means at the end of a piston working stroke the stacked assembly of impregnated fibrous material will dissipate a large part of the shock of the stopping of said piston.

17. An explosively actuated tool according to claim 16 wherein the elongated rigid member has disposed thereon a plastically deformable member disposed between said piston and said shock absorbing means.

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